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The Institute of Vitreous Enamellers

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and

The Foundry Trades' Equipment and Supplies Association

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More About Wear

There are some properties of a material—cast iron, for example—notably corrosion resistance, heat resistance and especially resistance to wear, which users frequently want expressed in quantitative terms and for the measurement of which they often express a desire for a standard test. Such a demand completely misconceives the situation, for, as Mr. J. G. Pearce pointed out in a contribution to the recent discussions on lubrication, wear resistance is not a specific property of a material. It depends on the mutual action of two surfaces, an alteration of either of which would affect the wear on the other, and upon a multitude of other conditions, such as temperature, dry or lubricated surfaces, the presence of dust and air, and so on. Similar points have been made in a series of Papers forming a symposium on the wear of metals by the American Society for Testing Materials. H. W. Gillett says that wear resistance is not an inherent property to be measured in absolute units. It does not exist apart from the conditions of service. Hence there can be in the nature of the case no universal wear test, but a series of tests corresponding with the specific conditions of service. Thus, there had been evolved the type of test simulating service conditions, but carried out on a basis of close observation free from the accidents and variations occurring in ordinary service which would invalidate a real conclusion. In the same symposium D. E. Ackerman dealt with some of the important variables encountered in wear tests for cast iron, and concluded that a general-purpose testing machine is unlikely to be devised, and that tests must be made with care and interpreted with caution. W. E. Jominy writes on wear from the motor-vehicle standpoint. Results are given on a new wear test machine chiefly for grey cast irons. Many of the irons gave better wear figures than a hardened tool steel. Another interesting Paper concerns the wear of metals in the textile industry, by A. Palmer. A modern loom is compared with an older model weighing 12 per cent. more. Made primarily of cast iron and steel, the new model has 2½ times as much steel as the old, while the cast iron is 9 per cent. less. Thus in the modern machine the ratio of weight of steel to cast iron is 0.55 and in the old one 0.22. In the modern machine there are 1,166 pieces and about 600 wearing points. The remaining Papers concern wear from the points of view of power station equipment and railway working.

The Cost of Tenders

Many years ago, someone had the bright idea that if he reversed the custom of being approached by a salesman, by announcing his requirements publicly, then he stood a fair chance of obtaining his goods at the lowest possible price. No doubt this system apparently worked successfully for a time, but then came the realisation that, though the firm whose tender had been accepted made a profit, the supplying industry as a whole had lost more money than it had gained through the transaction, and if all business were so obtained the industry as a whole would become bankrupt. The repercussion was that the suppliers countered by limiting tendering to a few firms, and prices were quoted which took care of the costs of tendering of the unsuccessful ones. Mr. E. J. Fox dealt with this question when speaking last Friday to the Midlands Branch annual dinner of the Purchasing Officers' Association, and suggested that better prices can be given when only one firm is approached, and no tenders are issued. This system of tenders is abused in another way, that is, by a company asking half-a-dozen firms or more to submit layouts for a plant extension and then to announce that by picking out the best points of each and utilising the services of its own maintenance staff, the company can do the job cheaper. This is, of course, put forward as an after-thought, because if it was premeditated it would be the equivalent of obtaining services under false pretences. One cannot go the whole way with Mr. Fox, as his alternative scheme is just as likely to be found as defective in application. For instance, the firm selected might be so busy as to quote a non-competitive price, in order to adhere to existing delivery promises, or so slack that the inclusion of concentrated overhead costs renders the quotation abnormally high. The lower prices accorded for export business are sometimes due to the fact that the job has not been put out to tender and carries, as it should, only one firm's cost of preparing a tender. Buyers should realise that they themselves often increase prices by asking for a number of tenders, when all the time, through the incidence of reciprocal trading, they have no other intention than to give the order to one particular firm which places orders with the buyer's firm or one of its subsidiaries. If they are tied in this manner, they might at least be honest with industry in general. Now that there is an association of purchasing agents, it is suggested that they devote much consideration to the subject of reducing the cost of selling, which will ultimately be reflected in the reduction of the level of buying prices.

International Foundry Congress

The International Foundry Congress, as previously announced, will be held in Poland from September 8 to 17 under the distinguished patronage of the President of the Republic of Poland. The preliminary organising work is now so advanced that an outline of the programme can be given.

The formal opening of the Congress will be on Thursday, September 8, in Warsaw, and September 8, 9 and 10 will be devoted to technical sessions, a meeting of the Comité International des Associations Techniques de Fonderie and its sub-committees, as well as to visits to foundries in Warsaw and the neighbourhood.

On Sunday, September 11, the Committee is arranging for organised visits to the capital city of Poland and its museums, as well as for official receptions.

Monday, September 12, is to be devoted to visiting foundries in the industrial district of Poland. On this day two excursions will be arranged, one to Starachowice and Ostrowiec, the second to Upper Silesia. After these visits both parties will meet in Wegierska Gorka on September 14, leaving together for the mountainous region of Zakopane. September 14, 15 and 16 are to be devoted to excursions to the Tatra and Pieniny mountains, and a visit to the Wieliczka salt mine.

The last day of the Congress is fixed on September 17, and on this day a final session will be held in Cracow. Opportunities will be given for visiting the beautiful ancient capital of Poland, the city of Cracow, the Royal Castle Wawel and the famous Cathedral where the early Polish kings are buried, together with the most famous national characters, including the creator of modern Poland, Marshal Pilsudski.

A party of members of the Institute of British Foundrymen and ladies will be organised to participate in the Congress, and in due course all members of the Institute will receive particulars of the arrangements from the Secretary of the Institute.

Non-members of the Institute who are interested in participating are requested to communicate with Mr. T. Makemson, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3.

Newport Metallurgical Society

The fourth annual dinner of the Newport and District Metallurgical Society was held at the Westgate Hotel, Newport, on February 18, Mr. G. H. Latham (President) in the chair. The principal guest was Mr. S. R. Beale (chairman of Guest, Keen & Nettlefolds, Limited). Other guests included Mr. L. D. Whitehead, Mr. D. C. Lysaght, Mr. A. G. Webb and Mr. K. F. Carmichael.

MR. S. R. BEALE, proposing the toast of "Iron and Steel and Allied Industries," said he believed that the present slight slackening in demand was only normal; in fact, most people would be rather unhappy if they had to face the abnormal demands of 1937 in perpetuity. The happy conditions existing in the steel industry imposed upon the personnel certain obligations of self-control and sacrifice for the good of the industry and of the country as a whole if these conditions were to be maintained.

MR. G. H. LATHAM, in reply, said that the policy of the industry and of the Government had been fully justified by results. The work of the British Iron and Steel Federation, and its chairman, Sir Andrew Duncan, had materially assisted in keeping the industry stable, thus avoiding large increases in prices as demand increased.

Other toasts were "Allied Societies," proposed and responded to by MR. J. MYERS and DR. D. W. OATES respectively, and "Our Guests," proposed by MR. F. W. R. HARRISON and replied to by COUNCILLOR J. R. WARDELL, who made a pointed reference to constructional activity in the district.

The PRESIDENT, in the course of his concluding remarks, referred to the valuable work which had been done for the Society by Mr. T. Grey-Davies, Mr. H. H. Stanley and Mr. W. A. B. Whitehead.

New Refractories for Use in Open Hearths

FEDERICO GIOLITTI, writing on "New Types of Refractories for Open Hearths" in a recent issue of "Metal Progress," states that refractory bricks and fettling materials for open-hearth furnaces have been subject to important researches during the past few years in Europe and America. Primarily on account of the different qualities of raw materials, European industrial practice, based on the results of such researches, is frequently somewhat different from America.

Silica or dinas bricks are, by far, the most commonly-used refractories in European open-hearths. The well-known inconveniences connected with their use, especially in basic furnaces, are usually more than balanced by their relatively low price, owing to the wide distribution of good silica rock for their manufacture. For many years the best dinas bricks were made from German and Czechoslovak quartzites. Lately excellent results have been obtained with French, Italian and Spanish sandstones. The recent development and wider application of "black dinas" bricks (made of crystalline quartzites of very different qualities) have still further improved the resources in raw materials for refractory manufacture.

European practice for the manufacture of black dinas varies within wide limits. The proportion of CaO is generally between 1.2 and 2 per cent. The percentage of ferrous slag may vary within wider limits, on account of the larger range of its composition, but it is usually somewhere between 1 and 2 per cent. Charcoal or coke powder is generally used to about 1.25 to 1.60 per cent. as a reducing agent.

Notwithstanding their somewhat lower melting point, black dinas bricks usually give very good results, provided some caution is used in starting the furnace. When properly used, these bricks stand a greater number of heats, in most of the European furnaces regularly using them, than normally expected with the best regular silica brick.

A new type of silica brick has been manufactured in northern Spain under the name "Agata," using a rock for raw material having a chemical composition similar to that of agate, that is, silica containing small percentages of iron oxide. The quality of these bricks is considerably superior to that of any other silica brick commercially produced at present in Europe. Their softening point lies above 1,750 deg. C., their specific gravity is lower than 2.35, and their coefficient of expansion is much lower than that of any other commercial silica brick.

A comparatively new type of chromite-magnesite brick, the use of which is expanding rapidly, is "Siemensit," made from the molten slag produced in the manufacture of low carbon ferro-chromium by the Haglund process. The raw materials used are chromite, magnesite and bauxite; the bricks contain about 35 per cent. Cr_2O_3, 25 per cent. MgO, and 35 per cent. Al_2O_3. They have very high melting point (above 2,000 deg. C.), and a high resistance to the chemical action of either acid or basic slag. Exceptionally good results have been obtained with these bricks in open-hearth furnaces.

Zircon bricks are seldom used (notwithstanding their excellent physical properties) on account of their poor resistance to the chemical action of slags.

Soviet Orders for Great Britain

Soviet orders placed and purchases made in Great Britain during 1937 increased by about 43 per cent. to more than £25,000,000, according to preliminary figures issued by the U.S.S.R. Trade Delegation. Machinery and equipment accounted for over £8,500,000—about one-third of the total. In 1936 the orders placed amounted to approximately £17,500,000, of which machinery and equipment accounted for £2,500,000, or 14 per cent.

Random Shots

"Marksman" has been getting into hot water because last week's list of utensils for pancake-making did not include aluminium. "What sort of a kitchen is it that is unlivened by light and shining utensils of the wonder-metal?" writes a very aluminium-minded critic. This, of course, is what happens when one poaches on other people's preserves, and the wife says "It just serves you right." An unusually inquisitive visit to her domain revealed the fact that a steady modernising had silently but surely been going on for years (out of the house-keeping money?) and every single pan in the place is aluminium! Many cupboards had been added to the walls of a kitchen built twenty years ago, and what is more, every conceivable gadget had its own particular shelf. Out of all these cupboard doors there is only one with which "Marksman" is regularly familiar, and that is the one which conceals the month's supply of matches. His visits to the kitchen are usually confined to hasty missions of a thieving nature, and a certain recollection of childhood days prevents him from developing too active an interest in the running of the home. Having a father who was an official of the local gas company, the home was exclusively run by gas. All very efficient, with the most modern appliances that the times could provide, until electric vacuum cleaners came into vogue, then there was a constant weeping and gnashing of teeth because the business interests of the master would not permit of the house being wired for electricity.

* * *

"And," to return to the same critic, "if you wish to eat your pancakes hot, is not the solution to make and eat them yourself in the kitchen?" Ah, my dear propagandist, that is where it is impossible to agree with you, for the more modern and metallic a kitchen becomes the less one wants to linger in it. The worker in it is inspired to work, and the would-be diner is chilled by its highly mechanised aspect. The only kitchen worth feeding in is that of a farm house, with its glowing fire, scrubbed boards, and hams and herbs hanging from the ceiling. Until Easter, then, when there is some hope of doing this, "Marksman," at least, will stick to the dining room.

* * *

A visitor to the British Industries Fair, tiring of asking learned questions all day long, facetiously remarked to a man on one stand: "I see that you claim that stainless steel sinks!"

But that stand-minder was equal to the occasion in spite of the late hour.

"That is so, sir. It is also true that jam rolls and acid drops. Music stands and time flies. Niagara falls and sulphur springs. Moonlight walks and holiday trips. Indiarubber tyres and standard weights. Malleable irons, and high speed steels. The organ stops, and the world goes round . . ."

The wag had by this time fled, sorry that he had tried to be funny.

* * *

Scene at a restaurant in any exhibition in any part of the world. Very tired representative ordering his lunch. "I'll have a little of that, and this to follow, with that to finish with," said he, pointing to a variety of coloured stains on the tablecloth.

"MARKSMAN."

MR. EDWARD OTT, manager of the foreign department of Hadfields, Limited, has been appointed assistant secretary of the Sheffield Chamber of Commerce.

Feeding of Castings with Special Reference to the Steam-Pressure Method*

By BEN HIRD

What is the purpose of feeding certain castings? Feeding is an endeavour to overcome the defects caused by liquid shrinkage. All foundrymen and metallurgists have to face these defects, and strive to overcome them by various methods. They have always been one of the worst troubles experienced in foundry practice. It is probable that more thought, study and ingenuity have been concentrated on this subject than on any other connected with cast iron. Right back through the files of THE FOUNDRY TRADE JOURNAL, and from the first published Proceedings of the Institute of British Foundrymen the subject has been studied and discussed. Although it has been so thoroughly ventilated, and much light thrown upon it, it still remains a problem, especially with castings of certain design.

In 1912 R. Carrick gave a Paper on "The Use of Chills to Overcome Liquid Contraction." Later E. Longden dealt at length with this subject, also with the effects of gases causing these defects. Buchanan put forward his "box theory" in about 1910 or 1911, when he pointed out that liquid contraction in one part of a casting was due to expansion in another part, and in 1923 he gave a Paper, "Some Notes on Liquid Contraction," when he further developed this theory. In the same year the Ronceray "pencil runner" theory was described and discussed, and Smalley compiled a splendid Paper on "Volume Changes of Cast Iron on Solidification," in which he stated that "Cupola melted grey cast iron, of normal chemical composition, does not shrink on solidification, *if* poured with a sufficient degree of superheat and *if* cooled faster than a certain critical rate." The following year J. Longden gave an excellent practical Paper on "Some Considerations of Liquid Shrinkage in Cast Iron," and stated in one of his conclusions that "Grey iron shrinks about 4.5 per cent. of its liquid volume on crystallising."

Many other excellent Papers and discussions have been published on this subject. Those mentioned have been taken at random to show part of the range explored. Although many theories have been expounded, and useful remedies suggested, the defects still persist, and it is not claimed that the method of pressure feeding to be put forward in this Paper is a positive cure for all liquid shrinkage defects.

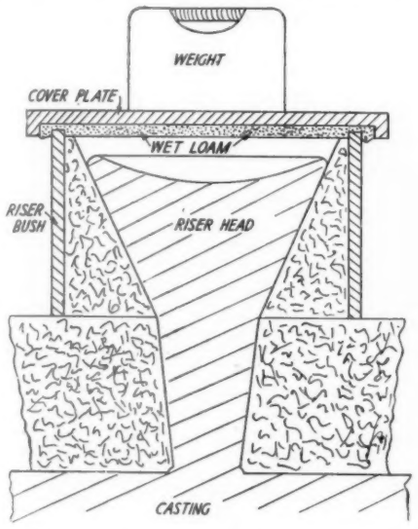

FIG. 1.—SECTION OF ASSEMBLY FOR STEAM-PRESSURE FEEDING OF A CASTING.

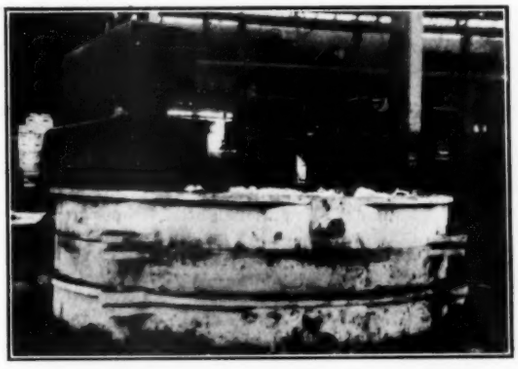

FIG. 2.—FLYWHEEL MOULD ARRANGED FOR STEAM-PRESSURE FEEDING.

FIG. 3.—RISER HEADS FOR HEAVY FLYWHEELS, SHOWING EFFECT OF STEAM-PRESSURE FEEDING.

Rod Feeding

Before introducing steam-pressure feeding, it is proposed, at the risk of being elementary, to deal briefly with rod feeding, probably the oldest method of feeding, and one which is common practice in many foundries.

In spite of its utility, the feeding rod has many failings, and some moulders appear to have a very hazy idea of its functions, whilst others shirk doing the job thoroughly because of the heat, with the result that the casting would have been better if the rod had not been used. Sometimes there is difficulty in placing the riser correctly over the thick part requiring feeding, and consequently the mould or cores are in danger of being struck with the rod, dispersing a quantity of sand and creating an unsightly lump on the casting. Some men move the rod up and down in the riser pump fashion, and think that they are feeding the casting in spite of the fact that they are pulling metal out of the mould as it sets around the rod; this they usually knock off with a short piece of iron bar. Actually they are creating a cavity instead of preventing one. Feeding with a rod is useless unless it is done efficiently, and correct rod feeding requires concentration of effort to prevent the metal in the riser setting sooner than the metal in the mould, and thus to allow the casting to feed itself from the liquid metal in the riser.

Practical Hints

The following procedure is recommended. The diameter of the feeding-rod should be suitable to the size of job and the riser, and will vary from a $\frac{1}{4}$ in. rod for an 1 in. to $1\frac{1}{2}$ in. dia. riser, to $\frac{1}{2}$ in. or $\frac{3}{4}$ in. for 2 in. to 3 in. risers. The rod should be well warmed before inserting it into the molten metal in the riser, then lowered gently until it touches the bottom of the mould, or any obstruction, then raised at least one inch, and the position noted carefully. The rod is then moved round the circumference of the riser with a gentle up and down movement, taking care not to go below the point noted. The rod should be revolved by the fingers as the feeding proceeds; this action keeps the rod clean by the rubbing action on the circumference of the riser, preventing the metal setting on the rod. The feel of the rod will indicate the solidification taking place in the mould, and coinciding with the setting of the metal the rod must be gradually lifted, and be taken from the mould before the final solidification takes place. If the metal in the riser shows signs of setting first, fresh hot metal must be poured into the riser-bush to enable the feeding to proceed until the mould has solidified.

This method of feeding occupies a considerable amount of time and labour, and is not a pleasant task. If a number of moulds have to be fed at the same time, it is often difficult to spare sufficient men from the shop to do the job, or spend the time doing it thoroughly.

Pressure Feeding

Pressure feeding is a method that can be recommended for most jobs. It eliminates the use of the rod, provides metal for the loss due to expansion of the mould, as mentioned in Buchanan's "box theory," and also for the shrinkage due to crystallisation dealt with by J. Longden. It retards the formation of cavities and porous places caused by gases, and assists the mould and core gases to escape into the open air through their proper channels, the vents. Most foundrymen will agree that iron is usually more dense and homogeneous in the lower parts of the mould due to the pressure exerted thereat.

The usual method of applying pressure feeding is by building up the runner and riser bushes (or in some cases the runner bush only) to more than the usual height above the moulding box top, in some cases heights of 12 to 24 in. being necessary to produce a sound casting, dependent on the amount of feeding the job requires. The objection to this method of feeding is the time taken to make up the runner and riser bushes, and the cost of melting and handling the extra metal required to fill them to get the head pressure.

Steam-Pressure Feeding

The steam-pressure method was introduced to obtain the benefits of pressure feeding without the expense in labour and material involved in making up high runner and riser heads. Over a long period of application the method has given satisfactory results on various types of castings. The method of application is very simple. Special cast-iron plates in the form of a shallow dish are made to suit the various sizes of bushes used. These plates should be sufficiently strong to be rigid without being too heavy to handle easily; from $\frac{3}{8}$ to $\frac{1}{2}$ in. section is suitable for most cases, and the dish is formed by a beading about $\frac{1}{2}$ in. high around the edges of the plate. It is important that the inside sizes of the dish should be at least an inch to two inches larger than the outside sizes of the bush.

The dish is filled level with wet sand, or, better still, loam. It is most important that the sand

* Paper read before the West Riding of Yorkshire Branch of the Institute of British Foundrymen, Mr. H. Forrest presiding.

be really wet. Runner and riser bushes are made up in the usual way, but care must be taken to ensure that the top edges of the metal bushes are flat and true, and if a surface grinder is available it is well worth grinding one edge of the bush. The wet loam plates must be prepared and placed conveniently near the moulds before the metal for casting arrives, together with a suitable number of box weights, 56-lb. weights being very convenient.

Immediately the mould is poured, the plates, loam side down, are placed on the runner and riser bushes, and the weights quickly dropped on to the plates, simultaneously if possible, or the metal may be pushed up into the unweighted bush and disturb the plate.

As soon as the weight is dropped on to the plate, the wet loam makes a seal between the plate and the bush edges, and steam is generated at once from the wet loam by the heat of the metal, and a pressure approximating that of the weight placed on the plate is produced. Feeding risers should be of a well-tapered funnel shape, having the neck connecting the riser to the casting as short as possible, thus ensuring a maximum time before the metal sets in the neck.

A point that must not be overlooked when pressure feeding is that, when extra pressure is applied to the liquid metal, the mould must be strong enough to withstand it; therefore, it must be weighted, or clamped very securely. Also precautions must be taken against bursting through, if portions of the casting extend up into the top part with only a small section of sand above them.

Fig. 1 shows diagrammatically a section of a steam-pressure-fed riser, and the other illustrations indicate some of the many applications of steam-pressure feeding. The method has proved very successful on heavy flywheels which are machined all over; they have turned out very free from porosity, and are much improved in balance. Cylinder heads which are subjected to water pressure have definitely benefited by steam-pressure feeding.

DISCUSSION

The discussion which followed the Paper began with a number of questions on points of detail concerning various jobs the lecturer had described, and gradually developed into a friendly argument between Mr. Hird and some of the Branch members as to the extent to which gases may, or may not, be found escaping from metals.

In answer to a query by MR. E. ILLINGWORTH, MR. HIRD said it was obviously desirable not to fill a riser to the level at which the seal plate would be fitted on. It was quite simple to stop ¾ in. or so from the top; otherwise, the man handling the plate might be burned by a splash of metal.

MR. H. BRADBURY questioned whether the use of a crane weight or other weights on top of a runner—as in one of the author's photographs—might be liable to cause uneven pressure, with consequent ill results.

MR. HIRD replied that the pressure was exerted on the whole area.

MR. A. S. WORCESTER asked was there any substantial difference between the metal that left the bushes from the nearest to the runner and that which was farthest away from it?

MR. HIRD pointed out there was not a great deal of room there, neither was there any quantity of water for generating steam. In any case one found a quantity of moisture behind the plate. The pressure persisted for quite a period. It was, he thought, the initial pressure for the first half-minute or so on a light job or for two to three minutes on a heavier job, that exercised the influence, rather than that over a period. He agreed that possibly in some risers the later metal might have cooled off somewhat. The loss of temperature between the time of pouring the metal into the runner and the time it came out of the riser was certainly a point that was not always given the consideration it deserved.

Application to Small Moulds

MR. D. W. HAMMOND inquired whether Mr. Hird had found the method similarly beneficial in small castings, operating on the lower pressures, as compared with the larger castings. Might one assume that in small jobs a 56-lb. weight would produce a similar action in the mould? Mr. Hammond asked also what type of metal was used, and whether it had a long or short solidification range.

MR. HIRD replied that he had used the steam-pressure method on some quite small jobs, and instanced the case of some cylinder heads which had given successful results. In some cases it was unsuitable, and he did not advocate it as a panacea. It was desirable in some cases to give it a trial, but if the metal actually rose into the bush it would be obvious as to whether the method was worth while.

The metals used in the jobs described (continued Mr. Hird) were all of a low phosphorus content, most of them with about 0.4 per cent. P and about 1.5 to 1.8 per cent. Si. The first job he tried on this work was a small engine casing, and the experiment was very successful. They did not get 1 per cent. scrap now, whereas they had been getting up to 75 per cent. before pressure feeding; and they had no chills or the like.

Temperature Measurement

MR. H. A. MACCOLL raised a question on a temperature drop mentioned by the lecturer, and inquired what type of pyrometer had been used. Being informed that it was an optical pyrometer, Mr. MacColl said there was liable to be a big divergence of results between different types of optical pyrometer, and he did not consider results with that instrument could be taken as reliable except as a matter of comparison if the use of the same pyrometer was continued. To his mind, the disappearing filament pyrometer was more strictly accurate.

MR. S. W. HANSON considered the optical pyrometer a good instrument as a guide for comparative purposes. He expressed surprise that Mr. Hird should need steam-pressure feeding for flywheels. He (Mr. Hanson) had had similar experience in this matter, and found a satisfactory method was to eliminate the riser and take, say, ⅛ in. or so increased depth of pattern-plate, and cast at a temperature, measured by optical pyrometer, of about 1,300 deg C.

MR. HIRD said he believed that with the pressure on the mould indicated it was definitely ameliorative. If for no other reason, it was worth while in the matter of separation of gases that entered the metal and the removal of gas cavities. The more pressure one exerted on a mould, the less were the losses due to these escaping gases. Again, if one could exert a pressure on a mould one must be assisting the operation of the core vents, and it would help to drive the gases through the vents provided. He agreed that with many types of castings adequate self-feeding was possible.

MR. HANSON said he felt that Mr. Hird's explanation in regard to the gases fully justified his case for steam-pressure feeding. All founders had to deal with this trouble due to gases, and anything that would help was well worth consideration.

Gas in Steel

MR. MACCOLL recalled that in the case of steel casting the more gas there was in the steel the less was the resultant shrinkage. That was just the opposite to the experience in cast iron.

MR. HIRD said that that was one cause of some foundry troubles. There was gas in steel, and when ironfounders used moulders' sprigs made of steel, the iron received the gases from the sprigs! It would cause trouble in machining, and they should, whenever possible, be avoided.

MR. A. W. WALKER doubted the possibility of gas being evolved from steel, and suggested that it was more a matter of the oxide.

MR. HIRD insisted that gas could come out of the steel, and he had tested and proved it to be correct. At one time he did much research work in calculating gases coming from steel and iron and tinned chaplets, and as a result he would state definitely that with many tinned chaplets one was likely to find that more than 25 per cent. had blowholes.

MR. WALKER objected that that was not the case if pure tin were used as a coating.

MR. HIRD insisted that if the gas-producing temperature were attained, bubbles of gas coming off from the feeding rod could be seen. There was a vast quantity of gas in all metals. A chill, when new, was nearly pure cast iron and froze the first skin of the metal very quickly, but every time the chill was used, the iron was burnt. When this happened, the graphite content was increased and that action was progressive until a state of affairs came about which did not freeze the skin of the metal so readily. Then the evolution of gases started, and the resistance was less, and actual bubbles of gas appeared. Gases would quite definitely come from a piece of solid iron.

MR. S. CARTER queried whether Mr. Hird really asked the audience to accept that theory. Had he tested the permeability of a piece of solid iron?

MR. HIRD said iron contained much gas, and it was constantly evolved. It could be proved by casting two layers of iron, one on top of the other. Above a certain temperature gas was evolved at a very considerable rate. He had given details of these experiments some years ago in his Paper on "Gases in Cast Iron," which Paper was printed in the Institute's "Proceedings."

Vote of Thanks

MR. CARTER, proposing a vote of thanks to Mr. Hird for his visit and his address, said that discussion had perhaps deviated from the original subject, but it had brought out many points from which they might all expect to derive some benefit.

MR. TURNER seconded.

MR. HIRD, in reply, said he did not regret the deviation at all. They were all seeking for more information, more knowledge and fresh ideas and experiences. The exchange of ideas was always helpful, and lecturers were as liable to learn something new as anybody else.

Marine Engineering Merger

Meetings of the debenture stockholders and shareholders of Richardsons, Westgarth & Company, Limited, the North Eastern Marine Engineering Company, Limited, and George Clark (1936), Limited, were held in London last week, to consider the proposed scheme of arrangement and amalgamation.

MR. R. S. MIDDLETON, at the meetings of preference and ordinary shareholders of Richardsons, Westgarth & Company, Limited, explained the reconstruction of the company's capital with a view to the amalgamation of the three companies, and said that the shipbuilding industry, upon the prosperity of which the company was largely dependent for its well-being, had been one of those severely affected by the prolonged and world-wide depression, with the result that financial reconstruction of the company had become necessary. There was no practical use in attempting reconstruction until conditions improved in the shipbuilding industry, but the last two years had seen a marked change for the better, and the board had had the matter under their active consideration. It would be difficult for the Richardsons, Westgarth Company alone to raise new capital on a permanent basis, but this could be made possible by amalgamation with other companies engaged in similar trades.

The scheme was approved at all meetings.

Copper Alloys Containing Sulphur, Selenium and Tellurium*

By CYRIL STANLEY SMITH

For many years sulphur and its congeners selenium and tellurium have been regarded as very harmful elements in copper and copper-rich alloys. Like many similar prejudices, this has been found to be partly wrong. All three of these elements actually have no great effect on the working properties of copper and its alloys, and are desirable additions in that they considerably enhance the machinability of alloys in which they are present. Because of their possible commercial importance, a study of the machinability and other properties of the pure binary alloys was made, as described in this Paper, and the effect of selenium on a large number of copper alloys was determined.

The current opinion regarding the deleterious effects of elements in this group undoubtedly arose because of occasional failures of tough-pitch copper containing unusually high tellurium, and because of the well-known fact that sulphur causes spewing and unsoundness in tough-pitch copper. Siebe,[1] also Deretchey and Margolina,[2] studied the effect of sulphur on copper, and showed that in the absence of oxygen it was present in the form of copper sulphide, which was less harmful to the properties than an equivalent amount of copper oxide. No data have been published on selenium and tellurium, although the statement is often made, following Eggleston,[3] that tellurium makes copper hot-short. Copper specifications call for only traces of these elements. Skowronski and Mosher[4] give data on the effect of selenium and tellurium on the conductivity of tough-pitch copper. In private communication Mr. Skowronski says that the samples were hot-forged from small castings and drawn to 0.081 in. dia., but it should not be inferred from this that these elements are harmless to the working properties of wirebars and commercial shapes.

Constitution

Sulphur, selenium and tellurium exist in their alloys with copper in the form of copper sulphide, selenide or telluride. These compounds are practically insoluble in the solid state and possess limited miscibility in the liquid state. The constitution diagrams have been studied by Bornemann and Wagemann,[4] Friedrich and Leroux,[5] and Chikashige,[7] from whose work the data in Table I are taken.

All these investigators were more interested in the middle of the diagram, and the copper-rich corner was very approximately determined. New analyses made to determine the maximum solubility of these elements in molten copper, at a temperature of about 1,200 deg. C., show that molten copper saturated with and in contact with the various compounds contains 1.55 per cent. sulphur, 4.11 per cent. selenium, and 18.15 per cent. tellurium.

TABLE I.—*Constitution.*

Element.	Eutectic. Composition. Per cent.	Eutectic. Temperature. Deg. C.	Maximum solubility in liquid state. Per cent.	Melting point of compound. Deg. C.	Percentage of element in Cu_2X.	Reference No.
Sulphur ..	1	1,073	2	1,155	20.1	5
Selenium ..	1	1,065	10	1,113	38.4	6
Tellurium ..	3	1,055	(3)	870	50.1	7

Microstructure

The microstructure of the alloys of copper with sulphur and selenium consists of a eutectic with or without primary copper or compound, depending on the composition. The appearance is almost identical with that of the copper copper-oxide system. The alloys with tellurium show a much coarser "eutectic" and form continuous strings around the grain boundaries. This difference undoubtedly is due to the fact that the second phase when it appears in equilibrium with copper is not solid, as in Cu_2S and Cu_2Se, but is liquid and forms at a monotectic rather than a eutectic point. Because of the low melting point of Cu_2Te and its tendency to form stringers around the grain boundaries, tellurium is rather more harmful to the hot-working properties of alloys than is selenium or sulphur.

The addition of a third element to alloys of copper with elements of the sulphur group will sometimes result in the elimination of the latter elements by the formation of insoluble compounds, which float out of the molten alloy on account of the lower density. As would be expected from the decreasing electropositive character of these elements with increasing atomic number, sulphur is the most readily eliminated of the three elements, and tellurium the least. In the presence of 40 per cent. zinc, only 0.2 per cent. selenium can be retained, but at least 0.6 per cent. tellurium remains, and probably more. Practically no sulphur remains in a copper alloy containing 40 per cent. zinc, and the addition of even as little as 0.2 per cent. zinc will cause some elimination of sulphur. If the third metal does not eliminate the element of the sulphur group it often results in a coarsening of the particles in the eutectic, and often changes their colour or even produces inclusions of a duplex nature.

* Extracted from a Paper presented to the American Institute of Mining and Metallurgical Engineers, Institute of Metals Division. The author is Research Metallurgist to the American Brass Company, Waterbury, Conn.

Casting and Working

The preparation of copper alloys containing sulphur, selenium and tellurium presents no particular difficulties. It is advisable to make the additions as copper sulphide, selenide or telluride, although tellurium may be added as the element, since it is not volatile at the melting point of copper. The compounds are readily made by charging into a warm crucible a mixture of copper turnings with the proper amount of sulphur, selenium or tellurium. Once started, the reaction will proceed rapidly, resulting in a coherent mass that can be melted and cast into suitable form for use.

No data are available on the influence of tellurium and selenium in the presence of oxygen; as, for example, in tough-pitch copper. Ductile castings can be made, perfectly sound and with a deep shrink, by merely melting the alloys under charcoal and pouring out of contact with air, or by deoxidising and pouring in the usual way. It is important, however, that the deoxidiser be not one with an extreme affinity for sulphur, such as, for example, calcium.

The presence of inclusions of Cu_2S, Cu_2Se and Cu_2Te does not interfere with either the hot-rolling or cold-rolling of copper alloys, except in rare cases. The particles are plastic both hot and cold and elongate on rolling in much the same manner as the piece as a whole. The stringers of inclusions can, however, be broken up and spheroidised by long annealing.

TABLE II.—*Properties of Copper Alloys Containing Sulphur, Selenium, and Tellurium.**

Alloy No.	Composition. Per cent.	Cold-drawn. Y.S. Tons per sq. in.	Cold-drawn. M.S. Tons per sq. in.	Cold-drawn. E. Per cent. in 1.4 in.	Cold-drawn. Conductivity, I.A.C.S. Per cent. at 20 deg.C.	Cold-drawn. Machinability.‡ Per cent.	Annealed 1 hr. at 600 deg. C. Y.S. Tons per sq. in.†	Annealed 1 hr. at 600 deg. C. M.S. Tons per sq. in.	Annealed 1 hr. at 600 deg. C. E. Per cent. in 1.4 in.	Annealed 1 hr. at 600 deg. C. Conductivity, I.A.C.S. Per cent. at 20 deg.C.	Annealed 1 hr. at 600 deg. C. Machinability.‡ Per cent.
1601..	99.990 Cu	22.6	23.2	21.4	99.7	15	3.8	14.5	60.0	102.1	22
1616..	0.15 S	22.1	23.3	14.3	97.8	24	3.6	14.6	53.6	99.3	20
1602..	0.23 S	22.9	23.4	15.0	97.6	33	3.4	14.7	51.4	99.6	21
1611..	0.54 S	23.4	24.2	12.1	95.1	41	4.0	15.0	50.7	96.7	81
1608..	0.78 S	25.2	25.2	7.9	91.6	45	4.9	15.5	45.7	92.5	70
1613..	0.97 S	23.7	25.7	8.6	90.9	45	5.0	15.6	45.7	91.4	70
1614..	0.11 Se	22.8	23.7	19.3	98.9	38	3.7	14.6	57.1	99.0	35
1603..	0.26 Se	23.0	23.7	15.7	98.0	64	3.9	14.5	55.7	100.1	63
1607..	0.48 Se	22.7	23.9	15.7	97.4	89	3.5	14.6	52.9	98.8	112
1606..	1.01 Se	22.3	23.8	11.4	94.4	95	3.9	14.9	48.6	95.6	140
1609..	1.44 Se	23.2	24.2	10.0	92.0	91	4.5	14.8	42.1	94.4	150
1615..	0.10 Te	22.6	23.7	15.0	99.5	29	3.5	14.6	53.6	99.8	30
1604..	0.25 Te	23.0	23.8	14.3	99.9	45	3.5	14.7	54.3	100.6	45
1610..	0.45 Te	22.6	23.7	11.4	98.2	58	3.6	14.7	51.4	99.9	72
1605..	1.05 Te	22.8	23.8	10.7	97.1	91	3.7	14.8	41.4	98.0	126
1612..	2.42 Te	22.8	24.8	7.1	94.5	91	3.9	14.8	—	96.1	134

* These alloys were hot-rolled from 3 in. to 0.625 in., annealed and cold-drawn to 0.5 in. in one pass. Gauge length of test pieces (0.357 in. diam.) was 1.4 in.
† Yield strength is the stress causing 0.5 per cent. extension under load.
‡ Machinability is expressed as a percentage of the machinability of leaded brass, measured by the drill test.

Mechanical and Electrical Properties

A series of alloys containing up to 1.0 per cent. sulphur, 1.5 per cent. selenium, and 2.5 per cent. tellurium was made by melting cathode copper under charcoal in a laboratory induction furnace and bottom-pouring out of contact with air after the appropriate addition. The entire lot of castings was hot-rolled in a commercial rod mill from 3 in. dia. to 0.625 in. and then cold-drawn in a single pass to 0.5 in. dia. (36 per cent. reduction of area). All the castings rolled perfectly and no hot shortness was observed. The tensile properties, electrical conductivities and machinability are shown in Table II and further data on machinability is summarised in Figs. 1 to 3.

Except for a curiously high drop with the first addition in each case (probably associated with the presence of impurities subsequently removed from solution on larger additions), the conductivity of the alloys is approximately lineally related to the *volume* percentage of the compounds present in the copper. The relation holds

for all three elements since the compounds are equally insoluble and of comparatively low conductivity. In terms of weight percentages, sulphur has the greatest and tellurium the least effect on the conductivity.

The tensile strength of copper is slightly increased by the presence of sulphur, selenium or tellurium, sulphur having the greatest effect. There is a corresponding reduction in the ductility as measured by the elongation. In no case, however, are the alloys brittle. The properties conferred on copper-base alloys by the addition of sulphur, selenium or tellurium most likely to find commercial utilisation is the high machinability of such alloys, unaccompanied by hot-shortness, as in alloys containing lead.

A series of crude tests was made to determine the machinability by counting the number of turns of a "standard" 0.25-in. drill required to penetrate 0.25 in. transversely into a rod of the alloy under test under various loads. The drills were replaced at the first sign of wear, and the results from each drill proportionately corrected to the basis of "standard" readings on leaded brass. A typical group of curves showing load *versus* number of turns is given in Fig. 1. These figures include a curve to show the comparison of the alloys of a commercial free-cutting brass of the following nominal composition: copper 62.0, zinc 35.0 and lead 3.0 per cent.

Fig. 2, in which is plotted against composition the number of turns of the drill at a constant load (86 lbs.) needed to make the standard hole, shows that in hard-drawn alloys the addition of small quantities of any of the elements sulphur, selenium or tellurium causes an improvement in the machinability, but that beyond 0.5 per cent. little further improvement is gained. Selenium is the most potent addition in small amounts, and in general is the best to add to copper alloys for improving machinability.

The machinability of the annealed alloys is shown in Fig. 3. Selenium and tellurium have the same effect that they have in the cold-worked alloys, but the action of sulphur is peculiar, in that small amounts actually decrease machinability and rapidly wear the drill. Although the sulphide inclusions serve to break up the chips formed, they do not act as a lubricant in the manner that copper selenide and copper telluride do.

Addition of selenium is not limited to binary alloys. Alloys of copper containing about 3 per cent. silicon with 0.5 per cent. selenium can be hot-worked and cold-worked almost as readily as selenium-free alloys and have similar tensile properties (with slightly less ductility), but their machinability is approximately three times that of the alloys without selenium.

The addition of selenium to the copper-nickel alloys is particularly attractive. Working with laboratory castings, it has been found possible to hot-roll alloys containing 20 per cent. nickel and 0.5 per cent. selenium, and alloys with larger amounts of nickel can be cold-rolled. As examples of the properties obtainable, the data in Table III are given, and show tensile properties and machinability (as determined by the drill test described above, and expressed as the reciprocal percentage of the number of turns necessary to drill a standard hole in a leaded brass). The alloy in question contained 20 per cent. nickel and 1 per cent. zinc with additions of selenium as stated.

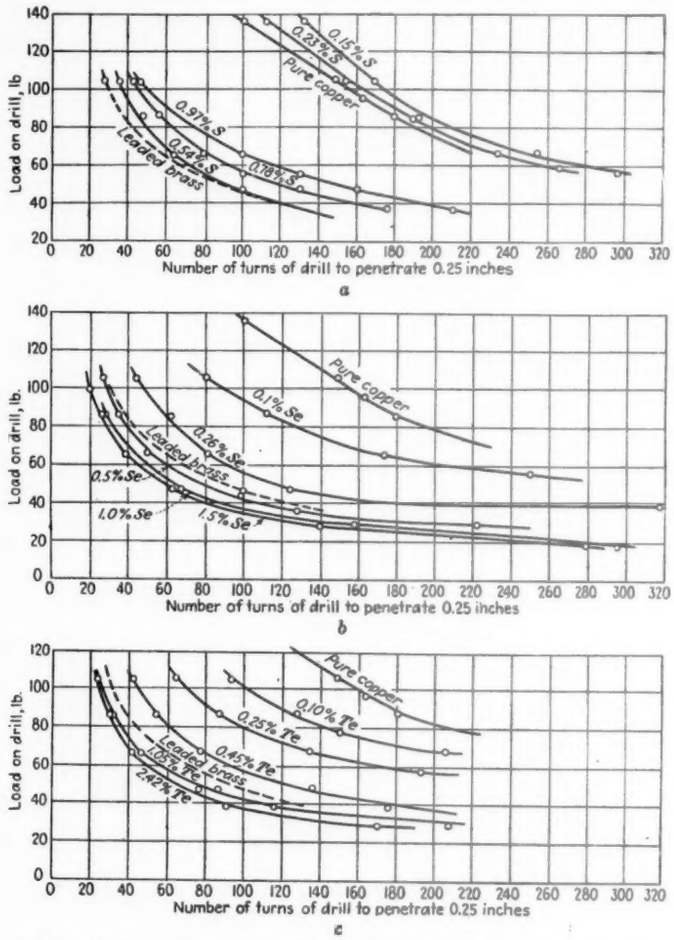

Fig. 1.—Curves showing Machinability of Various Alloys of Copper with Sulphur, Selenium and Tellurium.

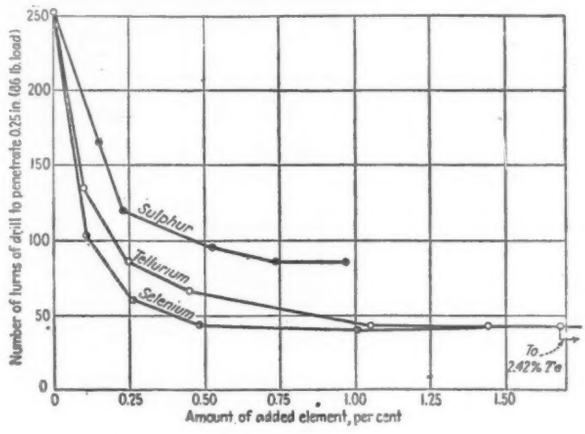
Number of turns of drill to penetrate 0.25 in (86 lb load)
Amount of added element, per cent
Sulphur
Tellurium
Selenium
To 2.42% Te

Fig. 2.—Effect of Sulphur and its Congeners on the Machinability of Copper (Hard-drawn).

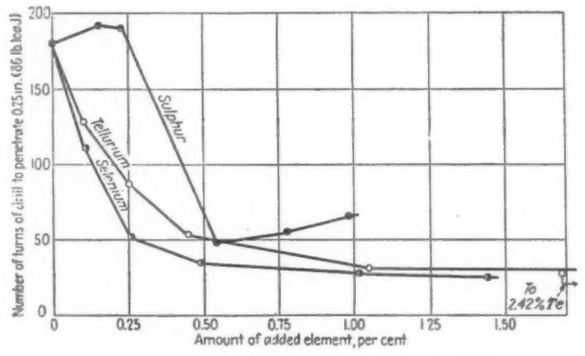
Number of turns of drill to penetrate 0.25 in. (86 lb load)
Amount of added element, per cent
Sulphur
Tellurium
Selenium
To 2.42% Te

Fig. 3.—Effect of Sulphur and its Congeners on the Machinability of Copper (annealed 600 deg. C.).

Table III.—*Tensile Properties and Machinability.*

Property.	No addition.		0.6 per cent. selenium.		1 per cent. selenium.	
	Hard.	Soft.	Hard.	Soft.	Hard.	Soft.
Yield strength, tons per sq. in. ..	29.7	7.1	28.6	6.5	28.0	6.4
Tensile strength, tons per sq. in. ..	31.2	20.3	31.5	20.5	30.1	20.0
Elongation, per cent. in 2 in. ..	18.3	55.4	11	50.0	10.0	48.5
Reduction of area, per cent. ..	67.6	78.3	42.7	59.3	33.0	52.8
Machinability	14.0	13.0	48.0	58.0	83.0	88.0

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2 E. Deretchey and S. Margolina: "Vestnik Metallopromshlennosti," 1928, quoted by Archbutt and Prytherch in "Effect of Impurities in Copper." London, 1937. Brit. Non-Fer. Metals Research Assn.

3 Eggleston: Trans. A.I.M.E. (1881), **10**, 493.

4 Skowronski and Mosher: Trans. Electrochem. Soc. (1932), **61**, 113.

5 Bornemann and Wagemann: "Ferrum" (1914), **11**, 276.

6 Friedrich and Leroux: "Metallurgie" (1908), **5**, 335.

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Sir Frank Smith, secretary of the Department of Scientific and Industrial Research, has been elected an honorary member of the Institution of Civil Engineers.

Some Aspects of Heavy Castings

By E. LONGDEN (Foundry and Patternshop Manager, Craven Bros. (Manchester), Limited)

(*Concluded from page* 186.)

PART II.—CAST IRON FOR LARGE CASTINGS

The qualities required in metal for the different types of large castings dealt with in Part I of this Paper last week, vary as greatly as for the smaller classes of castings. Each of the castings discussed in this essay holds a class of metal proved to be satisfactory. The analyses are given in Table I:—

TABLE I.—*Analysis of Metal for Large Castings.*

	T.C.	Si.	Mn.	P.	S.	Ni.
17-ton caustic pot ..	3.40	1.00	0.75	0.30	0.08	1.0
21-ton spindle casting ..	3.10	0.85	0.40	0.60	0.13	—
20-ton hydraulic cylinder	3.15	0.90	1.00	0.35	0.10	—
32-ton 94-in. lathe headstock	3.20	1.40	0.65	0.65	0.09	—
50-ton hammer anvil block ..	3.25	1.20	0.65	0.55	0.09	—

Generally, the use of alloying elements to improve the qualities of cast iron is growing. The improvements sought may be all or any of the following:—(1) Increase in strength, (2) soundness with uniformity of structure; (3) resistance to various thermal conditions promoting growth and disintegration of the metal, and (4) resistance to wear or corrosive conditions.

There are sound reasons for employing special metals to improve the flowing power of the metal and the service life of special classes of castings which enter the category of small and small medium weights. But for large and medium-weight castings, the incorporation of expensive metals in the cast iron is, to put it mildly, both unnecessary and extravagant.

Apart from the special-purpose metals containing large quantities of the expensive alloying or modifying elements, the alloy additions vary usually between 0.25 and 2.0 per cent. In such small percentages the added metals do not confer directly, to any serious extent, special properties on the cast iron. The substantial effects of alloying elements are indirect through their influence, mainly, on the conditions of the carbon and carbides, either as graphitisers or carbon stabilisers, and on the freezing rate of the metal. All these conditions can be also influenced considerably by the freezing rate of the metal, due to the section and mass of metal and the condition of the mould material.

Structural Control

The object of the author's attention has been to secure a defined structure in a particular class of casting. It may not always be possible to secure the desired structure and properties in small and medium lightweight castings, due to the rate of freezing preventing the reduction of the carbon and graphitisers to the effective percentages. In such cases the employment of modifying elements brings about the desired results. But with general heavy, medium and large castings, the thermal conditions are equally favourable to the production of the desired structure simply through the control of the elements normally present in the cast iron. The slower casting rate in heavy castings tends to level up heat gradients. The hot-mould process for the production of pearlitic cast iron may be cited as a case of control of the structure of cast iron through the normal elements present in cast iron and thermal conditions of the mould.

The metal specification for the caustic pot discussed in Part I includes 1 per cent. of nickel introduced as a graphitiser in preference to about 0.3 per cent. of silicon. Although this specification was met, the author is unconvinced of the need to employ nickel in a casting carrying a uniform section of approximately 3 in. The structure desired in caustic pots is one which will not be too dense to withstand thermal conditions of expansion and contraction due to the firing on the outside of the casting, and yet be uniform in structure so as to resist the corrosive influence of the caustic fluids.

It is the author's experience to expect little trouble from fluid shrinkage in metal of the hematite class, or with metal containing over 3.30 per cent. total carbon and phosphorus below 0.3 per cent. The analysis for the caustic pot altered by raising the silicon by 0.25 to 1.25 per cent. and omitting the nickel would be equally effective in producing the desired structure.

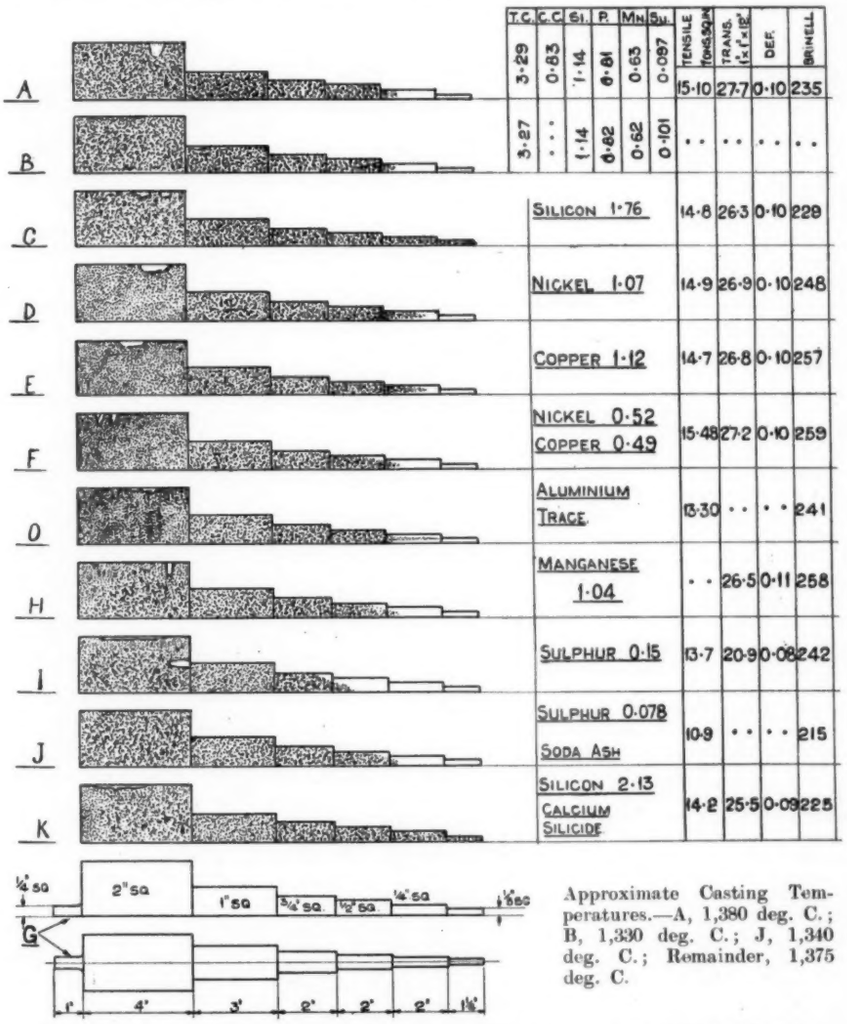
Many years ago it was the practice to pour pots similar to that shown in Fig. 2 in No. 2 hematite iron, because of the need to withstand thermal shocks. At the same time, the maximum life was not obtained so far as resistance to the caustic solution is concerned, because of the open grain structure common to hematite irons containing silicon above 1.50 per cent. The remedy lay in reducing the silicon content to about 1.20 per cent. and the total carbon to about 3.20 per cent. along with more exact control in the operations of heating up the pot in service.

Of far more importance than one or two points in silicon or carbon is the question of pouring metal into a mould in such a way as to avoid the collection of sullage at any particular point as previously stated. In many pots examined it was quite obvious that sullage porosity and not fluid shrinkage porosity was the direct cause of early failure due to penetration by the corrosive solution.

Influence of Elements on Structure

Fig. 18 is interesting in connection with the effects of adding special metals and metalloids to cast iron. This investigation was carried out by the author some three years ago. It is extremely difficult to compare the effects of various alloying elements. Usually investigation proceeds in stages whereby the effects of perhaps one or two elements on a base cast iron are tested at any one time. The many variables which might affect the true comparative results may be present on the occasion of next and successive tests.

The investigation had for its object the testing of the influence of various added metals



Approximate Casting Temperatures.—A, 1,380 deg. C.; B, 1,330 deg. C.; J, 1,340 deg. C.; Remainder, 1,375 deg. C.

FIG. 18.—INFLUENCE OF COMPOSITION AND PROCESSES ON THE PHYSICAL PROPERTIES OF VARIOUS TYPES OF CAST IRON.

and metalloids on the structure of cast iron. A step casting designed as shown in Fig. 18 proves a very suitable example to work on, disclosing as it does so clearly the effects of the added elements on the structure and soundness. Tensile and transverse test-bars were poured at the same time as the step casting. All the test castings were poured from the same melt of cast iron, the analysis of which is stated in the table included in Fig. 18.

Reduction of Variables

In order further to eliminate as many variables as possible, the step castings were moulded in the centre of a square core box, using black sand and dried so as to avoid any longitudinal joint flash and its influence on freezing rate. The whole of the test moulds were made from the same batch of sand and rammed as near as possible to the same density. After ramming the step pattern was withdrawn endways in the direction of the heavy end, and through the side of the box. The mould just accommodated the full length of the pattern, so that the ends were exposed. The large end was closed by a flat core carrying a standard-sized in-gate of ¼ in. square section, as shown at G, Fig. 18, to which was linked a down-gate and pouring basin. The small end was closed by a core, except for a very fine outlet gate or vent to allow air to evacuate from the mould, thereby ensuring that the metal was not impeded in filling the small ends of the mould by gas pressure. The moulds were just warm when poured.

With a view to holding and controlling the temperature of the molten base cast iron, crucible melting was resorted to. Two sets of tests were poured without any additions. The desire was to introduce 1 per cent. of the metals, nickel, copper, copper-nickel and manganese, and sufficient aluminium (1 oz. per 10 lbs.) to influence graphitisation. It was hoped to raise silicon in one test by the addition of ferro-silicon to about 1.50 per cent. and again further raise silicon in another test to about 2 per cent. by the addition of calcium silicide. The remaining two tests consisted of sulphur reduction by the use of soda ash, and sulphur increase by the introduction of flowers of sulphur.

All the intended additions were weighed and heated in readiness for when the molten cast iron was taken from the furnace. A number of refractory-lined and heated hand-ladles were prepared and marked on the lining to indicate the amount of base metal to be poured therein.

With everything ready, the metal was taken from the furnace, tested for temperature, and measured quantities of molten cast iron were poured into the several hand shanks, into which had been placed the heated alloying elements. One ladle contained no added material. The moulds were then poured together, with the exception of the soda-ash treated metal, which required most time for reactions to complete, and one of the two sets of tests without alloying elements. This last test was deliberately poured at a much lower temperature than the rest. The soda-ash treated metal would also be poured at some 20 deg. lower than the other tests poured at the same time.

The chart (Fig. 18) indicates, in the test A and B, the structure and properties obtained from the metal without any additions of modifiers. B was poured at 50 deg. lower temperature from the remains of the metal after the various test moulds had been cast. The analysis of the test-bar B varies a little from that of A. The following is a summary of the results of the experiments:—

A shows that graphitisation had penetrated about 30 per cent. down the ¼-in. section.

B indicates a slightly lower carbon precipitation penetrating about 20 per cent. of the ¼-in. section.

C with the silicon addition turned out completely grey throughout all sections.

D carrying the nickel addition created graphitisation down to approximately 70 per cent. of the ¼-in. section.

E with the copper content is remarkably similar to *D*. It will be noted that the copper content is a little higher at 1.12 per cent. as against 1.07 per cent. in the case of the nickel test.

F test reveals a new phase. With nickel and copper a hardening of the metal has taken place. Graphitisation is less than in the tests without additions, showing that somehow nickel and copper together in the same alloy have acted as a mild carbon stabiliser and not as graphitisers when employed separately.

O, which includes aluminium, shows that a core of graphite penetrates nearly the full length of the ¼-in. section.

H, with manganese at 1.04 per cent., indicates that graphite precipitation is reduced. White iron had penetrated the ½-in. section by about 10 per cent.

I test clearly shows the hardening effect of the increased sulphur content. White iron had penetrated the ¾-in. section.

J is soda-ash treated, producing a lowered sulphur content, and shows that white iron had slightly penetrated the ½-in. section, indicating that softening effect of the lowered sulphur had been more than offset by the lowering of the silicon to 1.08 per cent., 0.06 per cent. being eliminated during desulphurisation.

K test with the calcium silicide addition produced a silicon content of 2.13 per cent., resulting in graphitisation throughout the step section. Furthermore, a 1/16-in. section gas-relief riser gate leading from the ⅛-in. section end was also grey.

The table of Fig. 18, showing the physical and mechanical test results, confirms the state of the structure of the various examples, with the exception of the soda-ash treated metal J. It is difficult to understand why the hardness value and tensile test results are so low in J. The Brinell hardness test was taken on a ⅛-in. depth machined surface located on the centre side of the 2-in. section.

In conclusion, the author wishes to express his gratitude to his company through Mr. J. R. Greenwood, chairman and managing director of Craven Brothers, Limited, machine tool engineers, Reddish, Manchester, for facilities and permission to prepare this Paper. His thanks are also due to Mr. Hopwood and Mr. Hampson, members of the foundry staff, for help in the preparation of photographs and lantern slides.

(Concluded from next column.)

wright Memorial Hall in Lister Park. The Conference Banquet and luncheons would be held at the Connaught Rooms, and an "open night" and conversazione at Bradford Technical College. On the Friday there would be a motor drive into some of Yorkshire's most beautiful country.

The meeting unanimously confirmed a recommendation of the Council that Mr. A. S. Worcester—a Past-President—be elected as the President of the Branch for the Conference year, the year in which Mr. Joseph Hepworth, M.P., their Immediate Past-President, was to be President of the Institute. As Mr. Worcester's formal election to the Branch Presidency would not occur until the annual meeting at the end of April, Mr. Worcester was at once nominated President-Elect, so that he could officiate in connection with the Conference Fund Appeal to be issued shortly.

HOPEFUL PROSPECTS of improving the company's business in South Africa were mentioned by Mr. F. W. Firth, chairman of the Brightside Foundry & Engineering Company, Limited, when he spoke at the annual staff dinner which was held at Sheffield recently.

Notes from the Branches

East Anglia.—A meeting of the East Anglian Section of the Institute of British Foundrymen was held at the Stuart Hall, Norwich, in conjunction with the Norwich Engineering Society, on February 7. Some 60 members and visitors were present. Mr. Glover presided, and MR. S. E. DAWSON, F.I.C., gave a Paper on "The Melting of Cast Iron in the Rotary Furnace," which has previously been published in THE FOUNDRY TRADE JOURNAL.

In opening the discussion, the CHAIRMAN said the fact that the products of combustion did not come into contact with the metals was very interesting, as this tended to maintain the purity of the finished product. He was surprised at the shortness in length of the furnace, and would have thought better results would have been obtained by having it longer.

MR. L. J. TIBBENHAM said he had wondered whether he should change his view with regard to the rotary furnace, but did not think he would at present, though he appreciated that the rotary furnace had many advantages.

MR. DAWSON, referring to the question of a longer furnace, said he doubted if this would effect an improvement. The heat absorbed by the lining would result in a lower temperature, because the mass of heat was spread over a larger area of lining. The object was to obtain the heat at the point where it was wanted, *i.e.*, underneath the bath. The highest temperature was obtained with the smallest amount of lining. The question of cleanliness of the bath was important, because the quality of the metal was dependent upon the foreign matters which were present in cast iron. The improved results obtained by cleansing the cast iron from slag inclusions were great. In the furnace which had been described the metal was held for such a time that separation could take place. The longer the metal was in the furnace the greater the improvement which took place. Moreover, the removal of gases had a great improvement on the quality of the iron produced. If a foundry did not require to make special alloy irons for high strength there was no point in having a special furnace. Steel-mix irons were being obtained from the cupola, but where high-temperature alloy cast irons were needed the cupola could not be used; if these were essential the rotary furnace was an economical proposition.

MR. C. H. KAIN asked for information as to the size of material that it was possible to charge into the furnace, and what happened when steel turnings formed a considerable portion of the charge.

MR. DAWSON said the size of the material was restricted to the size of the charging door and the length of the furnace. When using steel turnings, these were charged initially, and after that the carbon was added; more turnings could then be added until the desired composition was attained. Generally speaking, the shrinkage of iron produced in the rotary furnace was not different from that produced in the cupola for equal compositions.

Replying to a question as to the normal tapping temperature of the metal from the rotary furnace, the lecturer pointed out that it depended upon composition. The maximum temperature was 1,600 deg. C.

A vote of thanks, proposed by MAJOR GLENDINNING, and seconded by MR. T. REAVELL, was accorded to the lecturer.

West Riding of Yorkshire.—Preliminary plans for the annual conference of the Institute of British Foundrymen, which is to be held at Bradford from June 14 to 17 next, were reported by Mr. S. W. Wise (hon. secretary) at the last meeting of the West Riding of Yorkshire Branch. Mr. Wise informed the members that the proceedings would include a civic reception by the Lord Mayor and Lady Mayoress at the Cart-

(Concluded in previous column.)

Core Drying Ovens

EXAMPLES OF CURRENT AMERICAN PRACTICE

In no branch of foundry work have the technical advances of late years been more marked than in the case of core and mould drying ovens. It is now fully appreciated that the production of sound castings depends to a considerable extent upon the correct drying of cores and moulds, and this appreciation has been followed by marked improvements in drying ovens.

How great was the need for improvement in some of the older types of oven is quite obvious, for there are instances recorded of temperature differences of more than 100 deg. C. between one part of the oven and another, as a result of which cores placed nearest the firebox would be burnt, while those placed farthest from the source of heat would be insufficiently baked. As a consequence of the need for uniform and accurately maintained temperatures, increased attention has been paid to other forms of heating which will ensure these advantages, particularly gas and electricity, irrespective of the cost of such fuel, while in compensation every effort has been made to reduce labour costs by the adoption of conveyor ovens.

Where formerly capital cost and fuel cost were the two main factors upon which the selection and purchase of a mould or core drying oven depended, there is now an increasing disposition in the foundry industry to regard both these factors as entirely secondary to the production of good work with the minimum of rejects. It is largely due to this changed attitude that the use of such fuels as gas and electricity has developed so greatly, as the benefits to be derived from such expensive fuels are mainly to be assessed from the improved quality of the work produced.

The foregoing does not imply that the question of the relative costs of different fuels is to be entirely disregarded, but merely that it takes its proper place. It has to be borne in mind, moreover, that the subject of fuel consumptions of drying ovens is one on which there does not exist a superabundance of data which are capable of being applied to each individual case. In this connection, one of the largest makers of drying ovens, whose productions embrace the four methods of heating involved gives the following table for rough-and-ready work as representing average practice in regard to the weight of cores or moulds dried as compared with a given unit of fuel consumption:—

Ratio of sand to iron ..	1:1	1:2
Electricity, per kwh. ..	10–15	8–10 lb.
Town gas of 530 B.T.U., per c.f.	1–2	0.75–1.5 lb.
Fuel oil, per gallon ..	400–600	300–500 lb.
Coke, per lb.	25–40 lb.	15–25 lb.

Naturally, the overall results are affected by a variety of factors, such as the shape of the cores, whether of small or large cross-section, the kind of sand, the binder used, while in the case of the oven itself the thickness and the nature of the wall insulation, and whether it is to be worked intermittently or continuously, are also points which have a material influence upon the results.

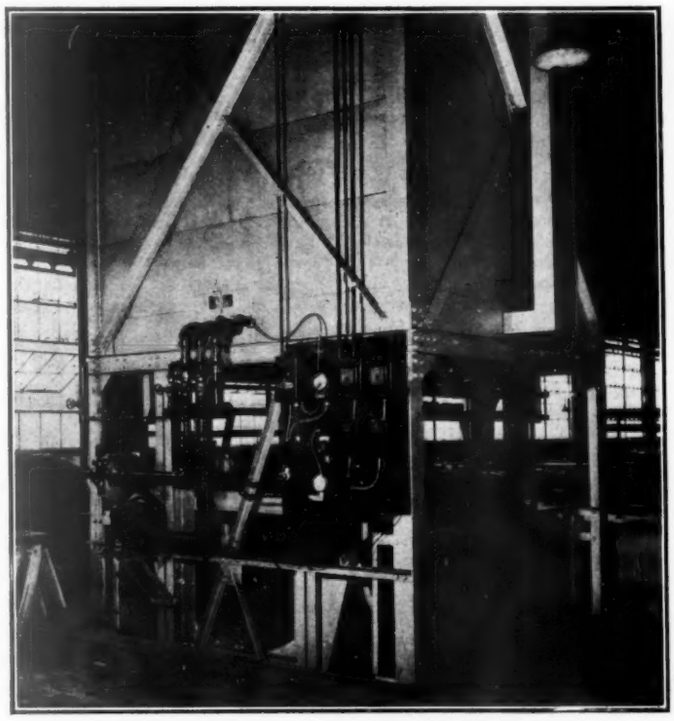


Fig. 1.—Vertical Conveyor Core-Drying Oven, showing Gas-firing Controls.

In the U.S.A., which is the home of large-scale production and repetition work, there are to be found a greater number of large and unconventional drying ovens than in this country. A type which is coming into general favour both in the States, Germany, and in this country, is the vertical conveyor oven, also known on the Continent as the "paternoster" type. This consists of a series of suspended cages or shelves, carried on a suitable endless chain in a vertical oven which is divided into two shafts. In this system the cores are loaded on one side of the oven, carried upwards firstly through a preheating zone, then through the heating zone, and finally through the cooling-down chamber. There are now large numbers of this class of vertical conveyor oven at work equipped both for gas and electric heating, and the illustration reproduced in Fig. 1 shows one of the gas-heated type of American manufacture. This particular oven is 24 ft. 3 in. high, with a cross-sectional area of 9 ft. 6 in. by 10 ft. 4 in., which is provided with 18 core racks each having three shelves, and operates at a working temperature of 260 deg. C., the output being 5,000 cores and 4,500 core plates per hr. The fuel employed in this case is natural gas, and the consumption for the above output is 1,500,000 B.T.U. per hr.

This class of furnace is stated to give a very much improved quality of core due to the close and uniform temperature rendered possible by gas heating, and in each case it has reduced in a remarkable degree the trouble previously experienced through burnt or insufficiently heated cores. With this type of oven, it is, of course, possible to vary within very considerable limits the amount of heat applied to the heating zone, and the heating and cooling cycle can also be varied by reducing or increasing the speed of the driving motor controlling the conveyor.

Silicon Brass

K. N. Lebedev, writing in "Liteinoe Delo," No. 8, 1937, gives details of a silicon brass (85 per cent. Cu, 10 per cent. Zn and 5 per cent. Si) which was investigated in regard to its mechanical properties, casting properties, resistance to corrosion and anti-friction properties. A large number of castings were made for studying the behaviour of the alloy under actual working conditions. These castings could be divided into two groups, the first group consisting of complicated fittings intended to withstand pressures in some instances of up to 350 atmospheres. The excellent fluidity of the silicon brass resulted in perfect reproduction of the most complicated details. Most of the rejects failed to pass the hydraulic test owing to the presence of cracks, but such defects can be reduced by rational methods of melting and casting. The second group of castings represented parts from which a high degree of anti-friction properties was expected. It is claimed that the results point to a very wide field of application of silicon brass for the casting of fittings and other parts in place of gunmetal, since it possesses much better casting properties and mechanical properties, a lower specific gravity and absolutely satisfactory anti-friction properties.

"New Fields for Industry"

The Commissioners for the Special Areas have issued a booklet "New Fields for Industry, the Special Areas and the Opportunities they Offer for Industrial Development." This booklet is addressed to the man who contemplates the development of a new industry or the extension of his manufacturing business. For more than two years the Commissioners for the Special Areas have devoted much thought and the expenditure of considerable sums of public money to repair the damage to public local services—housing, sewerage, water supply, hospitals and the like—arising from the effects of the depression, and already heavy commitments have been entered upon for these purposes. The Commissioners came to the conclusion that further action was essential to bring new industries to the people who needed work, in those regions that were once centres of national prosperity and will be so again. The scheme which is outlined in these pages was therefore formed to bring new industries into the Areas. It is a scheme based on an eminently practical appeal. Industry, in seeking new sites for production, demands two things above all—low cost of operation and a prosperous milieu in which to achieve and maintain its own prosperity. The first demand is met—and generously met—by a saving of capital outlay and a reduction of overheads which allow an industrialist to operate in the Special Areas on terms that are probably the most favourable to be obtained anywhere in the world. The second is met by the very nature of the scheme as a whole. The new industrial policy to which the scheme is directed aims at the development of specific centres of new industry in the form of Trading Estates and the development and re-establishment of other parts of the Areas in the manner most suitable to their location and natural resources.

The Radiant Tubular-Element System of Heating as Applied to the Industry*

By A. A. STRAUB

Perhaps the title of this Paper would have been more accurate if it had read, "The Possibilities of the Application of the Radiant-Tube System to the Vitreous Enamelling Industry." The actual application of the radiant-tube system to this industry is still to some extent in the testing stage, although the results obtained are particularly encouraging.

The question may be raised as to why more rapid advance has not been made in this specific application. The answer is that the author's company, the Lee Wilson Engineering Company of Cleveland, Ohio, were the pioneers of this system of radiant-tube heating, which found an immediate and vast demand in the heavy industries, to the extent that in the short space of three years capacity has been laid down by this company alone exceeding three million tons per annum output, mainly in the heavy industries. This has been due entirely to the exceptional results obtained with this system in both economy and control.

The demand made on the technical staff of the companies concerned in coping with this huge output has necessarily limited the time available for investigating the technique of application to vitreous enamelling, but it is pleasing to announce that concurrent with this development in the heavy industries a considerable amount of research work has been undertaken with the radiant tube as applied to fusing furnaces for both sheet and cast iron ware and throughout the usual temperature range of, say, 700 to 950 deg. C.

It is not intended to follow conventional practice of packing this Paper with a catalogue and illustrations of furnaces, but rather to endeavour to give a concept of the fundamental principles involved and the possibilities of this new form of heating. An exterior view of a furnace gives very little information, and it is, therefore, the physical and economic phases of application that will be dealt with.

The broad questions to be considered are as follow:—

(1) What is the fundamental difference between the radiant-tube system of heating and the present known and standardised methods of heating as applied to fusing furnaces?

(2) What are the specific advantages of such a system as compared with the present standard type of muffle?

(3) Is such a system equally applicable to batch and continuous furnaces?

Fundamental Differences

The answer to the first question is that the radiant-tube system of heating constitutes essentially an immersion heater. The fusing chamber proper is merely a thoroughly insulated box in which internally-fired tubes are immersed; the external surfaces of these tubes, possessing high heat emissivity, radiate direct on to the work as charged and also set up convection currents which, if the tubes are properly applied and spaced, ensure thermal uniformity.

It will be appreciated that such a method eliminates high temperature radiation inherent in the use of external heating flues around the chamber proper, and also that a metallic tube is not subject to leakage and consequent gassing, which is a prevalent trouble in the use of sectional muffles. Interposed between the tube proper and the ware as charged there are no great masses of brickwork which inevitably cause a time lag between the method of control of the furnace and the effective heat delivery to the charge.

A common condition of practice with the ordinary fusing muffle, when fitted with automatic control, is that the time lag, *i.e.*, the temperature response of the chamber proper to an altered fuel rate, often exceeds the fusing period and, therefore, the resultant control of the chamber is out of phase with the actual fuel control, to the extent that a compromise setting has to be established.

As against this condition, with the radiant-tube system of heating any slight variation in fuel rate, as accomplished automatically by the modulating type controller, reflects itself in the chamber with a minimum time lag of ten seconds, thus adjusting the requirements of fuel input to the requirements and demand of the load.

Under this heading, the point may be raised that an electric furnace will do all which is claimed in the foregoing. This is not quite the case, as electric controls are essentially "on" and "off" controls—either the current is full on or full off; the resistors are giving their full emissivity or nothing, whereas with the radiant-tube system, which at its full capacity will give a heat emissivity per unit area slightly higher than an electric resistor, this emissivity may be damped from maximum rate down to zero in small decrements, the duplication of which in an electric furnace would necessitate the introduction of wasteful resistances which would lower the efficiencies very considerably.

Advantages to be Derived

Dealing with the second question—"What are the specific advantages of such a system as compared with the present standard type of muffle?"—the specific advantages may be outlined as follow:—

(1) The internal dimensions of the chamber as compared with the dimensions of the heated section of an externally-fired muffle are less.

(2) The reduction in the superficial area of the external radiating surface, together with the lower temperature at which this surface is maintained (*i.e.*, within a few degrees of load temperature), reduces radiation losses by at least 20 per cent. as compared with standard muffle practice.

(3) The elimination of large masses of refractory material between the source of heat generation and delivery results in a reduction in time and fuel required for heating up, together with a saving in fuel by the synchronisation of heat generation with delivery due to the elimination of time lag. One of the outstanding features of this furnace in practice is the remarkably rapid recovery to normal working temperature after charging the load.

A further advantage is that the tubular elements have now stood the test of some three years continuous application under conditions quite as severe as those encountered in the vitreous enamelling industry, with negligible maintenance costs; in fact, the established life has now been sufficiently long that if tubes which are still in good condition had to be replaced entirely, they would have already justified the economics of their application.

Batch and Continuous Working

The answer to the third question—"Is such a system equally applicable to batch and continuous furnaces?"—is in the affirmative. One of the natural advantages of this form of radiant-tube element as developed by the Lee Wilson Engineering Company is its flexibility of application. It may be installed with the same facility as an electric resistor, with the added advantage of the graduating method of control. Waste gases from the tubes, which may be of the recuperative or non-recuperative type (according to the possibilities of the ultimate use of the waste gases), may be applied in the preheating zones of continuous furnaces or for drying or other auxiliary processes.

Fuel Consumption

Following these remarks a natural question is as to what all this means in pounds, shillings and pence. What are the final ascertained results, and how will such figures affect the balance-sheet of a typical vitreous enamelling works? Anyone experienced in the industry will agree that it is very difficult to make general statements which are of any real value in regard to fuel consumptions. In the periodic or batch-type furnace, providing there is a reasonable distribution of the load, assuming comparatively cold perrit bars, cast-iron work at, say, 750 deg. C., and three to four heats per hr., the actual thermal efficiency obtained exceeds 50 per cent., that is, in relation to total weight of metal heated. Thermal efficiencies as high as 60 per cent. have been obtained. Taking a practical working figure of, say, 45 per cent., this results in a fuel consumption of 0.6 cub. ft. per lb. with 475 B.T.U. gas. In practice results varying from 0.55 cub. ft., under the most favourable conditions of loading, to 1 cub. ft. per lb. have been obtained. In connection with the plants with which the author has had personal experience, a mean figure of 0.75 cub. ft. per lb. would represent a fair average. On higher temperature sheet metal work no consistency of results has been found, due to the widely varying conditions obtaining throughout different works.

The basic condition is, of course, efficiency of heat generation and distribution, and the final result in efficiency as related to the ware is dependent upon the arrangement and form of loading, as the actual heat delivery into the chamber from the radiant tubes as compared with the heat in the fuel reaches efficiencies as high as 75 per cent.

* Paper presented before the Midland, Northern and London Sections of The Institute of Vitreous Enamellers.

The First Installation

The first Lee Wilson enamelling furnace was installed at a large stamping and enamelling works in Northern Ohio. The furnace chosen for this installation was a standard 5 ft. by 12 ft. It is one of a battery of three new furnaces, all of which are well insulated and automatically controlled. The other two are used as controls to give accurate data as regards fuel consumption, quality of work produced, and operating economies effected. This conversion to the tubular type of heating was started in December, 1935, and was first lighted up in January, 1936, and with the exception of some time for making changes has been in operation since then. Accurate data has been taken with regard to throughput and fuel consumption since the time of lighting up.

For the first two or three months, the tube-type furnace could not be considered as having constant operation. During this period it was necessary to make quite a number of minor changes in burner equipment and the placing of corebusters, etc. Being conversant with the major difficulty encountered in batch-type enamelling furnaces, namely, the large quantity of heat lost at the door, ample provision was made to ensure sufficient heat-liberating area in the fore part of the furnace.

Approximately 40 per cent. of the heat-emitting area is located in the first 3 ft. of the furnace; in addition to having large areas for heat emission in the front of the furnace, it also gave the additional advantage of being able to burn much more gas in these first tubes than in the tubes towards the back wall. This added advantage gives absolute control of the furnace from end to end.

Counterfiring

The tubes are counterfired, *i.e.*, alternate tubes are fired from each side of the furnace. This method of counterfiring, coupled with the fact that the greatest radiating loss from the tubes is at their point of entrance to the furnace, gives definite uniformity from side to side, and the temperature differential at any point on the landing wall level is negligible.

The tubes enter from both sides at a point 3 in. above the hearth, and leave the furnace through the opposite wall at a point 2 ft. 9 in. above the hearth level. Adequate space for expansions of the tube, both in the furnace and at the entering and leaving points, has been allowed, and to date there has been no difficulty whatever in respect to cracking of the tubes.

With a similar class of ware being charged in all three of these furnaces and over a long period of time, it has been found that fuel consumption is reduced from 1,050 cub. ft. of natural gas per hr., on the muffle type, to 830 cub. ft. for the tube-type furnace. The operators state that the furnace is faster, and that they are securing at least one more charge per hr.; also, the quality of the ware is in every respect equal to the muffle-type furnace.

Due to some initial troubles several of the tubes were burned out, but a change in the design of the landing wall has overcome this difficulty.

In the batch-type enamelling furnaces referred to, the weight of the load proper does not bear on the tube elements, but is taken direct on refractory landing walls. With certain systems of tube application an attempt has been made to use the tubes as landing walls, which method may easily result in excessive distortion of the tubes.

Corebusters

In firing this type of batch furnace, a standard Lee Wilson burner and corebusters are used. These corebusters are of vital importance in the satisfactory operation of the burners. They are formed of sillimanite and are placed in the horizontal section of the tube, at a point dependent upon the total maximum volume of gas to be introduced. They assist in reclaiming as much of the heat as possible from the products of combustion, and increase the convection transfer to the tube. The tubes are of the standard chrome-nickel alloy, and are formed from sheets, which are rolled to shape and atomic-hydrogen welded. Initial efforts were with the cast type of tube, but due to casting defects, limited elasticity and other difficulties inherent with the use of castings, rolled material which is formed to shape and welded is now used entirely.

Then, too, the fabricated tube has the great advantage of uniform wall thickness, ensuring uniformity of temperature on the outer surface of the tube, and enabling the Lee Wilson tube to be manufactured only $\frac{1}{8}$ in. thick. It can be seen readily that this thin wall section has an outstanding advantage, as it reduces the temperature differential between the inner and outer surfaces of the tubes. This temperature differential has been checked at 975 deg. C. outside temperature to 1,002 deg. C. inside temperature.

Continuous Malleablising Furnaces

This thin wall section and rapidity of heat transmission through the wall has enabled the Lee Wilson tubes to be successfully used in continuous malleablising furnaces, where operating temperatures of 1,020 deg. C. in the work are required. Up to the present time no tube failure has been experienced at the welded joint.

To date, there are in use, and on order, over 12,000 such tubes and burners, in applications ranging from drying operations, ferrous and non-ferrous annealing and enamelling, to even the extreme high-temperature conditions of continuous malleablising furnaces.

Fuel Considerations

At this stage a few comments as to the fuel problem may be of interest. For instance, what kind of fuels can be used with the radiant-tube system? Does such a system impose any limitation as to the selection of fuels? Generally, these tubes are fired by clean gas which may be, as in the United States, natural gas, coke-oven gas, ordinary town's gas, cleaned bituminous gas, anthracite gas or hot gas derived from the combustion of coke. With a clean prepared fuel gas, it is customary to apply this gas to the tubes by means of burners, suitably designed for the calorific value and characteristics of the gas. Where clean gas is not available, and in such instances as would involve an undue capital expenditure in the installation of a producer plant for the manufacture of clean gas, then the Lee Wilson radiant-tube system can be operated very satisfactorily from a common combustion flue, fired by small coke producers built integral with the furnace setting.

In the latter case where the gas is pre-ignited before admission to the tube, individual element controls are provided on the outlet of each tube, thus regulating the gas flow and heat delivery into each element and providing the same efficiency and effectiveness of control as is possible with the individual burner system. These controls when using solid fuel, after initial calibration, may be linked up to an automatic controller without difficulty.

Conclusions

Summarising these remarks, the heat as delivered to the chamber is on the basis of the highest efficiency yet attained in combustion engineering practice. The utilisation of this heat so efficiently delivered must necessarily depend upon the particular form of loading in each case. The author's province and interest does not extend beyond the construction of a heat-delivery chamber and the efficient delivery of heat into this chamber. Beyond this point works' technique necessarily comes into play.

DISCUSSION AT MANCHESTER

Maintenance Costs

Mr. A. G. Read wished to know the cost of maintenance of a furnace similar to the one described. Taking, say, a 15 ft. by 4 ft. furnace, or a 12 ft. by 4 ft. furnace, which was the average type used in the industry in this country, he asked if Mr. Straub could give any figures as to the maintenance cost, so as to include, if necessary, the replacement of the tubes. Of course, the tubes might not require any attention for perhaps one year, but, taken over a number of years, they might have to be entirely replaced. Did the furnace referred to in the Paper require a chimney? There were occasions when the position of the chimney on a furnace made a great deal of difference.

Upkeep of Tubes

Mr. Straub thought that, with a 5 ft. by 15 ft. furnace the total tube and burner cost would be about £600. When a tube failed, it had not necessarily to be replaced in its entirety. In a case where there was a pinhole, or a hole of the size, say, of a halfcrown, the tube could be removed and a patch welded on. The tubes were initially welded. After careful investigation, he had come to the conclusion that the maintenance cost of a 5 ft. by 15 ft. furnace would be about £60 per year, as far as tubes were concerned. The furnace should last indefinitely, as there was no flame impingement and no erosive influence. The total investment in tubes was about £600. He knew of some metallic tube elements which had been installed in January, 1934, and which were still in actual operation. They had been patched several times. For observation purposes one tube was taken out and broken, but no diminishment was found in the wall thickness. It was considered that the tube should last for at least five to ten years longer. With regard to the chimney in the muffle-type fired furnace, it was necessary to use a somewhat reducing flame for temperature distribution throughout the length of the muffle, and operate the furnace under pressure. This was not the case with the tube type. The tubes were fired to the absolute ultimum; so far as CO_2 generation was concerned, there was no CO and no free carbon or smoke in the combustion products at all.

No Chimney Needed

In the case of a sheet metal annealing furnace which had been under his observation, there were about 4,000 tubes firing under a roof, and there was no provision to take out the products of combustion, because they were non-toxic. Therefore, a chimney was not required. If the products of combustion were to be utilised for drying purposes, some means had to be devised of gathering the products of combustion from the point of emission from the tubes to transport them to the drying ground.

Relative Efficiencies

Mr. W. H. Whittle said it had been mentioned that, with a 12 ft. by 5 ft. furnace it would take the equivalent of 2,100 cub. ft. of town gas on the old type of furnace, and about 1,660 cub. ft. with the tubular type of furnace, per hr. Had Mr. Straub any figures as to weight or load per hour, or for what weight per hour that quantity of gas would be sufficient?

Mr. Straub replied that that point had occupied the attention of furnace manufacturers for a long time. To have some proper index for fuel consumption for the vitreous enameller had been a very great bone of contention. So many square feet of ware went through the furnace per hour. The ratio of weight to the actual ware throughput per hour, and the weight of the individual pieces per hour had to be considered. The figures he had given were taken from actual experience. It would be misleading to give figures of gas used merely for one month's period run. Three furnaces were built at the same time. There was a failure in the muffle, and his

firm contracted to put in tube-type elements. Over a period of a year and a half, with the same throughput going through each of the furnaces, the figures he had stated were the result. This experience was gained in dealing with such articles as pots, pans, kettles, coffee percolators, etc. The comparison he had given with regard to the fuel consumption per lb. throughput was taken from the best muffle-fired furnace that he knew of, as against the tube-type furnace.

The problem in regard to vitreous enamelling furnaces, as well as a great number of other furnaces, was the heat-emitting quality into the furnace per hour. With a carborundum muffle there was a relatively rough surface which was not conducive to good heat emission by radiation, which was the only form there was inside the muffle. As compared to a ½-in. chrome-nickel alloy tube, the ratios were 300 to 1. Three hundred times the heat was emitted into the furnace from ½-in. tube per heat unit as was obtained with an ordinary carborundum muffle.

Tube Changing

The CHAIRMAN (Mr. H. Whitaker) asked what was the necessary length of time occupied for the purpose of taking out a tube.

MR. STRAUB said that, as yet, his firm had not evolved an entirely suitable method of replacement of the tubes in vitreous enamelling furnaces. The fact that tubes were not everlasting was well recognised. What was being striven for was a design of enamelling furnace in which the tubes could be readily replaced without throwing the furnace out of actual operation. This result had been achieved in regard to the heavy industries job.

MR. H. JUKES inquired whether Mr. Straub would state the thickness of the insulation necessary for a radiant tube furnace, and the approximate length of the tubes for a 15 ft. by 5 ft. furnace.

Insulation Problems

MR. STRAUB replied that in the case of the furnaces installed they were 22½ in. There were 9 in. of ordinary firebrick, which was highly essential. It was not possible to utilise very light insulating refractories on the inside owing to the fact that there was no heat-storage capacity in the tubes. There must be heat-storage capacity in the furnace lag. In the case of an ordinary muffle there were approximately 2½ tons of heat-storage capacity in the size mentioned by Mr. Jukes. Therefore, it was necessary to build up the heat-storage capacity in the refractory lining inside the furnace. There was a remarkably efficient return, because the moment a batch of cold ware was put in, the refractory dropped in temperature, but started to rise within five or ten seconds. The furnaces with which his firm had made their first and second trials were in series. One had three furnaces in line, and the other two, and they were of fairly recent construction. They had 9 in. of firebrick, 9 in. of light-weight insulating refractory, and 4½ in. of common red brick. If he was to design a new furnace, rather than make an adaptation of an old furnace, he would carry out the same idea.

MR. A. K. WILLIAMS remarked that the figures for fuel consumption, namely, 16,000 as contrasted with 20,000 cub. ft. of gas, were in the proportion of 4 to 5. Mr. Straub stated that the radiation was in the ratio of 300 to 1. The two statements did not seem to tally, because if the radiation, or the heat emittance, was of the ratio of 300 to 1, the fuel consumption should be relatively less.

MR. STRAUB said that what he wished to convey was that the heat conducted through the tubes, as far as speed and heat input ratio were concerned, was 300 to 1. The figures could be checked by the conductivity per hour. This was with 28 chrome and 12 nickel-chrome steel. With a carborundum muffle of the ordinary box type, the thickness varied from 1¼ in. down to 1 in., or 1½ in. to 1 in. In the type referred to in the Paper the thickness was ½ in.

In regard to the total combustion figures, while it was correct to state there was higher penetration through a chrome-nickel tube than there was through a carborundum muffle, it was necessary also to calculate the ratio of the emissivity through the tube, because there were certain fixed losses such as radiation, flue losses, etc., bringing it down to about 10 per cent. less fuel consumption for the Lee Wilson type than with a carborundum muffle and the radiation area from a muffle was much greater. This was the only figure the company had ever claimed commercially. The flue losses were less in the case of the Lee Wilson furnace, because it was not necessary to maintain nearly as high a furnace temperature through the thin walls as it was in the case of a carborundum muffle. The radiation losses were somewhat less, because there was a high inside working temperature.

The figures stated were actually obtained over a period of 1½ years approximately. The actual figure referred to in the question was 300 times the heat emissivity from a ½ in. chrome tube as compared with a carborundum muffle, 1 in. thick. The figures could be checked by almost any text book.

Tube Growth

MR. W. B. CLEVERLY asked whether the answer to Mr. Williams' question was not that the radiating surfaces of the tubes was much less than on an ordinary muffle. This was why the high emissivity was necessary. He noted that the lecturer had examined a tube and found no thinning; conversely, was there any thickening due to oxidation? There was no burning away, but there might be oxidation in the inside of the tube, tending to thicken it, making it spongy and lowering its conductivity. Was there any possibility of ash being carried over to the tubes and lowering the thermal conductivity in the case of coal-fired furnaces?

A further point upon which he would like information was as to whether the gases in the tubes were under pressure or draft, *i.e.*, was there a blowing fan at the burner end or a suction at the outlet? Furthermore, with regard to the corebusters he understood that the core had to be broken up, but did that imply that the length of flame development was from the burner up to the corebuster, and then from the corebuster onwards it was the products which were doing the heating? He presumed that "diffused" combustion took place up to the corebusters and from thence turbulent flow of the gases.

MR. STRAUB said that as far as oxidation was concerned no thinning had been found in the wall of the tube. They were all acquainted with the effect of heat on chrome-nickel tubes, but he would like to point out that when he used the term "chrome-nickel" it could not be defined in a very broad statement. A great number of tests had been carried out, and the best alloy discovered so far was chrome and nickel 25 per cent. and carbon under 0.30 per cent. In the event of the carbon content rising above 0.30 per cent. there would be a thickening, but below that ratio there was none at all. The only thing which made stainless steel stainless was the fact that a very thin oxide was formed at the start, which acted as a protective film. It was not progressive or cumulative. He had experienced no difficulty with regard to oxidation.

In the case of a vitreous enamelling furnace, having regard to the exceedingly high localised temperatures, the chances were that the operation would be well above the scaling temperature of the alloy, and that it would be burnt through. Personally, he knew that it would be burnt through. This was the reason why his company were not putting out their furnace until they had developed a definite method of changing the tubes.

There was a certain amount of trouble in regard to ash carry-over, and provision had to be made to scoop it out of the bottom of the tube. The moment there was a deposit of so bulky a material as ash, or a heat-storage material such as ash, there were created very highly localised temperatures. Much had been said with regard to his company's type of furnace respecting suction or pressure throughout the tube. In the first place, with the tube there was the effect of stack height. If the door of the furnace was opened there was a definite neutral pressure, and if the attempt was made to hold a lighted match at the entrance to the tube, the stack effect was such that it would pull it out. There was a stack effect of 33 in., which at such highly elevated temperatures would draw any gases from either the outside atmosphere or from the inside of the furnace. In the event of a hole opening up in the tube it would draw the air from the inside of the furnace. The probable place at which there would be a tube failure would be near the point of firing, near the burner.

The corebusters merely acted as inert material placed inside the tube in order to divert the products of combustion to the outside walls and so give up their heat there. His firm now used a modulating type of controller. The location and amount of corebusters placed in a Lee Wilson tube were dependent on the maximum heat input in the tube.

MR. W. B. CLEVERLY assumed that there was turbulent combustion right from the burner. If a definite output was required, or it was necessary to force the furnace, the length of the flame development would need to be increased, and the temperature of the outgoing gases would also be increased, with a greater increase in the heat losses.

Combustion Factors

MR. STRAUB said that that was not the case. The total amount of heat emitted per sq. in. on Lee Wilson tubes could be kept down to 40 B.T.U. per hour per sq. in., which was slightly in excess of an electrical resistor. In actual practice, in the case of the front tubes of a vitreous enamelling furnace, that figure was approached, but it stood to reason that there must be a differential effect between the exit gases of the tube and the furnace atmosphere itself. It was necessary to be higher on one side or the other, or else there would be a flow in the other direction. If it was desired to increase the amount of heat liberated for each tube, the number of corebusters in the tube was increased also. This created a greater scrubbing effect. The products of combustion leaving the tube at the elbow, where it left the furnace, were in the ratio of 55 deg. C. to 70 deg. hotter than the furnace itself.

Another method employed by his firm was to use straight tubes, horizontally applied above and below the hearth in a malleablising furnace. It was possible that these tubes would burn out. In the case of the malleablising furnace, by means of which the time of the process was reduced from seven days to 24 or 30 hours, and where the cost of handling was reduced because it was not necessary to pack the materials, and with a proper gas inside the furnace, the possibility of burnt-out tubes was not regarded as being of any great importance.

Concerning the diffusion type of burner, an article was published by the American Gas Association to the effect that 40,000 B.T.U. could be burnt per cub. ft. per hour with diffusion flame burning. If that was exceeded, turbulence occurred which defeated the purpose in view.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to Mr. Straub for his Paper.

Analysis of Cast Iron Suitable for Vitreous Enamelling

Mr. H. Cowan's Paper on "The Analysis of Cast Iron Suitable for Vitreous Enamelling," which has been presented to several sections of the Institute of Vitreous Enamellers, and which was printed in our last supplement, was particularly well received.

At the London meeting, which was presided over by Mr. V. C. Faulkner, the discussion was opened by MR. C. P. STONE, who agreed with the lecturer that the analysis of metal was not of major importance. He had himself proved that on more than one occasion, but had found the sand used in moulding to be an important factor, and particular importance should be attached to the actual moulding of the casting.

Stressing the plea for closer co-operation between the founder and the enameller, Mr. Stone recalled that it had been his practice to arrange meetings every morning between the foundry and enamelling-shop foremen, in order that they might appreciate the troubles to be overcome. Those meetings had been of the greatest value, and the difficulties were overcome without recourse to alteration of the mixtures, but by alteration to runners and sand practice. They did not bother very much as to whether the carbon content varied or whether the manganese was 0.5 or 0.6 per cent. because they often obtained equally good results with common metal as with special metal from the middle of the melt.

Personal opinion was that some indication should be given to the buyer of enamel as to the coefficient of expansion and also its refractory index. If a casting had an expansion coefficient of 3.1 the expansion coefficient of the enamel which was to be applied to it should be relative to the process; if it were for direct application the expansion coefficient should be below that of the casting, but if for use on a matte coat, it should be above.

If metal would grind and polish successfully and was the kind of material which would be used in the past for nickel plating finishes with good results, it could be, despite composition, enamelled successfully. All castings should be examined after blasting and before enamelling, as it was surprising how much should go to the scrap heap instead of into the enamelling shop. Castings must be cleaned so that they were quite free from sand or moulding defects, and, above all, they should be processed and finished rapidly.

It was important that the lecturer's demand for clean grey-iron castings be interpreted as castings free from slag, blowholes and dirty gates, and for direct application of enamel—particularly in acid-proof finish—free from screws (cast iron) and heavy lugs.

MR. A. B. KENT agreed that it was true that sand-blasting was a very important item, but he asked whether Mr. Cowan would agree that annealing was the most important item, because to a casting which had been sand-blasted very indifferently, one could apply a dark enamel and secure a good result, whereas a good result could not be obtained when a light enamel was applied. He agreed that if the annealing were correctly done, and if the sand-blast and spraying were also satisfactory, yet the results were not of the requisite standard, it was necessary to change the type of frit used.

A Clean Casting?

MR. KENNETH HILL pleaded for a definition of the word "clean," because in the world of sand-blasting there seemed to be so many differences of opinion as to what was meant by the word. The appearance of a casting when sand-blasted with flint or sand was entirely different from its appearance when sand-blasted with metallic abrasives. The size of the abrasive used also influenced the appearance of the casting. It seemed necessary to arrive at a definition of a clean casting, so that the enamellers or the examiners of the casting would know what to look for. Of the many plants he had visited, he knew of only two in which castings were examined after sand-blasting; in the remainder the matter was just left to the sand-blaster, who, being paid at piecework rates, was merely interested in getting out the work.

MR. ROGERS asked how one could decide, by looking at a casting, whether or not it was suitable for annealing—apart from the question of cracks.

Limiting Scope of "Inquests"

MR. GRAY, JUN., expressed his disagreement with the author's statement that the enameller always blamed the foundryman when things went wrong in the enamelling shop. If the foundry executive were to spend a few weeks in the enamelling department, he would soon appreciate that many difficulties were dealt with and overcome about which the foundry knew nothing. There were a number of troubles which were peculiar to the enamelling shop. For instance, if pinholing occurred, the enameller did not immediately blame the foundry, but set about correcting the matter, not because he was worried as to whether it was the fault of the foundry, but because he was responsible for production and must produce a good job. If his efforts to solve the problem failed, he would then in all probability ask the foundry to help, but it was very often found that, when this stage was reached, the foundryman suggested that the trouble was really in the enamel, and referred to such matters as spraying, etc., which the enameller had himself already checked up on.

Regarding the suggestion of varying the time for annealing, he considered this was not practical in many works having large outputs. Although he agreed that it might help to vary the time of annealing, it must be remembered that many firms held a very large number of castings in stock and they could not refer back to the analysis of each batch of castings and say that as one batch was cast three months ago it must be annealed for 30 minutes, and that another batch cast two months ago must be annealed for 20 minutes. Everyone was aiming at complete control in his own department, and the foundry's aim should be in that direction so that the type of castings made and delivered to the enamelling shop should be consistent, and the same annealing time and temperature should be suitable at all times. There might be, of course, exceptions in very abnormal times, but he did not consider that as a general rule it was practical to make variations in the annealing times to suit particular casts.

He could not agree that the foundryman was always on more solid ground than the enameller, as a foundryman having made a casting could have it dressed either by wire-brushing or by being passed through the "tumbler" and the casting to all appearances would be sound and have a good surface; but when the enameller subjected it to a thorough sand-blasting at 60-lbs. pressure a considerable number of difficulties might be exposed which the foundryman had never seen.

The Case of Baths

MR. J. T. GRAY said he agreed that inasmuch as a bath was practically all surface, if the analysis was at fault from an enamelling point of view then boiling or difficulties would be experienced over all the bath. When an enameller examined a bath for defects he first paid attention to the surface immediately over the footlugs, as at these points there was a considerable difference in thickness, which meant a different rate of cooling. If there was any difficulty through occluded gases their effect would be more likely to show at these spots.

Regarding American foundry practice, he said that owing to the low fluidity of the metal used in America some of the large foundries had a number of cupolas situated at different points around the foundry; the fluidity of the iron did not allow for it to be carried a long distance in the ladle as was the practice in most large foundries in this country.

"So-called Annealing"

The heat-treatment of castings prior to enamelling was not really annealing and he always referred to it as "so-called annealing." While this process might cause some physical change in the iron, the annealing of metal was really a matter of time plus temperature, and he had always considered that the heat-treatment of castings prior to annealing was for the purpose of driving out occluded gases and the loosening of burnt-in sand.

When the wet process of enamelling on cast iron was first introduced, he considered at first that it would be essential for the enameller to make a close study of cast iron analyses, etc., but after some years of working in close collaboration with metallurgists and foundrymen he had come to the conclusion that the analysis of the metal was not so important a fact as having a clean, sound casting. Having obtained this, the two main considerations for good cast-iron enamelling were annealing and sand-blasting.

Mr. Gray said he was very interested in Mr. Hill's comment, and he, like everyone else in the enamelling trade, would welcome a definition of a clean casting. He also realised the difficulties in arriving at a satisfactory definition in this respect.

THE CHAIRMAN (Mr. V. C. Faulkner) remarked that in the lecture Mr. Cowan had considered sulphur, phosphorus, manganese, silicon and carbon, in that order; but in discussing carbon he had become quite complex and had dealt with the various sorts of carbon. On the other hand, when dealing with sulphur he had not mentioned manganese sulphide or iron sulphide; the idea that they were dealing with pure sulphur was rather absurd. It was quite possible that iron sulphide or manganese sulphide could react with the complex silicates associated with glass. When one desulphurised cast iron by means of soda ash one did many things in addition to purely desulphurising. He asked for Mr. Cowan's considered opinion as to whether desulphurising, in the broadest sense of the word, was likely to be beneficial to the manufacturer of light castings destined to be enamelled.

It might also have been pointed out in the lecture that phosphorus did not exist as phosphorus in the castings, but as an eutectic, which melted at, roughly, enamelling temperatures. It was possible that the phosphide eutectic in cast iron gave a "glue" by which the enamel adhered, and that theory to-day was being confirmed by reliable research.

The idea that nascent graphite could have any effect had been rejected as ridiculous. But it was perfectly plain, from the physical point of view, that nascent graphite would have an infinitely greater superficial area than graphite which had crystallised out in the ordinary way. Therefore, he suggested that physically it might have some effect. The lecture had dealt almost entirely with the chemical aspect; but the physical aspect must not be neglected. It was more than possible that if there were nascent graphite on the surface of cast iron it might possess either adsorptive or absorptive qualities

having a profound effect on the adherence of the enamel to the iron or the reaction between the enamel and the iron.

AUTHOR'S REPLY

MR. COWAN, replying to the discussion, commented that he had received the greatest encouragement from those from whom he had least expected it, whilst the chairman had damned him with faint praise! With regard to sand and facings used in moulding, he said that he could see no point in producing a good skin on a casting if that skin had to be cleaned off subsequently. In a casting which had to be treated by enamelling or by electroplating, soundness was essential. The use of coal-dust, plumbago, etc., in the moulds did not mean anything to such castings. If a particular sand and a particular dressing were used to produce a sound casting, well and good; but it was not necessary to use them if their purpose were to produce a nice blue skin on the casting, and he considered the time was ripe to destroy that fetish.

Defects were found sometimes under the skin of a casting, and he wanted the enamellers to send such castings back to the foundry. The very fact that an enameller proceeded with the enamelling of a casting (if it showed surface defects) implied that he must take the blame for anything which went wrong subsequently. There was no foundry executive who would not take the blame when he was confronted with a defective casting. If the enameller found that a casting was not sound before the ultimate firing, he should hand it back to the foundry, and should shut his shop rather than proceed to enamel it, because it was waste of time. If that were done, progress could be made.

Both Mr. J. T. Gray and Mr. Gray, jun., had taught him much about porosity, etc., in castings, and from time to time had proved that difficulties which had arisen were due to defects in the castings. His point, however, was that many troubles were wrongly attributed to the castings.

Importance of Annealing

As to the suggestion by Mr. Kent that annealing should be placed before sand-blasting in order of importance, he said there were many founders, particularly those dealing with black enamelling, who did not anneal their castings. One foundry had dispensed with annealing in order to compete with others—which was another way, perhaps, of saying in order to cut prices—and for the time being had succeeded. There were, however, even some well-enamelled castings which began to show signs of defects after exposure to the atmosphere for a week or two, due to cheap treatment in the early stages. He placed a high value on annealing; one might succeed in nine cases out of ten if annealing were eliminated, but trouble might arise with the tenth, which trouble would not have arisen at all if the other nine batches had been annealed. Many things could be done in an unorthodox manner, but one's fingers would be trapped eventually, and the cost of the troubles which would arise would be greater than the cost of doing the work in an orthodox manner initially. That was why he stressed the importance of annealing.

Sand-blasting

On one occasion he had been called to a works which was producing baths, and where complaints were made of pinholing and practically every other trouble that could possibly occur; of course, the foundry was blamed, because such troubles had not been experienced to such an extent before. However, he had studied the various operations in the production of a bath, in their proper order, to ensure that those operations were properly carried out. On examining a bath which had just been delivered from the sand-blast, he had found that it was not sand-blasted properly. He had chalked several crosses on one part of the bath, and had sent it back to be sand-blasted in the part bearing those crosses. When the bath was returned to him, however, it was properly sand-blasted throughout. The trouble was that, when the sand-blaster had found that the particular bath was being used for test purposes, he had immediately appreciated that his work was under suspicion.

It was very difficult to define cleanliness in relation to the sand-blasting of a casting. It was a matter which must be judged by experience. In one works he had noted one sand-blast plant operating at a pressure of 30 lbs. per sq. in., and another at 80 lbs. per sq. in. But if a pressure of 30 lbs. per sq. in. was satisfactory, why go to the expense of using 80 lbs. per sq. in. pressure? A sand-blaster ought to be able to tell when a casting was clean. It was just as difficult to define cleanliness as it was to define the various properties of an enamel. A good deal of work had been done in connection with the resistance to impact and the thermal resistance of enamels. The aim should be to improve the quality of enamels and the methods of testing enamelled articles for mechanical strength, heat resistance, lustre, etc. All those properties would have to be defined numerically eventually. He believed that ultimately one would arrive at a measure of a clean surface, just as we were able to measure noise, etc.

In how many works were the men supplied with gloves for handling castings after sand-blasting, and in how many cases were the arrangements such that the castings were not handled at all after sand-blasting? In many cases one found that castings were made perfectly clean by sand-blasting, and then dirty hands were applied to them. He could almost forgive inefficient sand-blasting if the castings were not touched by hand afterwards.

Stored Castings and Defects

Commenting on the remarks by Mr. Gray, Jnr., with regard to the fact that some foundries held large stocks of castings and that the annealing conditions should vary according to the times at which the castings were made, Mr. Cowan said he would not accept the responsibility for the enamelling of castings made a year or two previously. He wanted to use castings which were made on the day before they had to be enamelled. There was no royal road to good enamelling. If castings came direct from the foundry to the annealing plant the variation in the time and temperature of annealing was very small. How many of the defects in cast iron were due to storing castings in damp places? The annealing conditions could not be modified on a production basis to meet variations in the castings.

It was true that design played an important part. With regard to the period required for annealing, he said there were several types of annealing. For example, one was merely a strain anneal, at a temperature much lower than was usually applied. One could ascertain from the microstructure of a casting whether or not it was annealed properly. When a pearlitic iron containing graphite and phosphide eutectic, etc., was annealed, it was found that the pearlite was almost completely decomposed. That was visual proof that annealing had taken place, annealing being decomposition of the pearlite.

Desulphurisation

With regard to the Chairman's remarks on manganese sulphide and iron sulphide, he said that if there were any iron sulphide present, he would suggest that the casting was not a good, sound, clean, grey casting. Therefore, he did not need to bother with it. He believed in desulphurisation, and he considered it very beneficial to cast iron, particularly when it was effected by the soda ash process. He agreed that the beneficial effect was not wholly due to the desulphurisation, although the metal was desulphurised. He liked particularly the agitation of the metal in that process, because he believed it to be invaluable in removing impurities. It also resulted in an appreciable amount of the graphite going into solution. He recalled that some years ago he had found that one founder used to put into the metal a piece of potatoe on the end of a stick so that it would bubble, whilst another had used a piece of galvanised wire to produce the bubbling or agitation. Desulphurisation was good because microscopically and mechanically the results showed it to be good. Whether this process was adaptable to light castings was another matter, however.

He had no wish to convey the idea that phosphorus was present in the form of phosphorus. He agreed that the phosphide eutectic had the lowest melting point of all the constituents in the cast iron composition. But surely enamelling was not carried out at a temperature of 950 deg., which was approximately the melting point of the phosphide. If that were done, the phosphide eutectic would run out. Presumably the chairman had had in mind some means of preventing the possibility of reaching a stage at which the phosphide eutectic would ooze out, and it was for the enamellers to work in that direction and to produce an enamel to be fired at a lower temperature. If they could produce an enamel which could be fused at a temperature of about 100 deg. lower than the fusing temperature of the average enamel to-day, many of the troubles of the light casting founder might be eliminated.

Presumably, when the chairman was referring to the surface area of the nascent graphite, he had meant that when graphite was in the granular form it had a greater surface area relative to its volume, and Mr. Cowan said that he would agree with that, but he could not refer to the precipitated graphite as being nascent. He would suggest that nascent graphite might mean new graphite just made from carbide, but he did not know of any information to bear that out. He believed the physical aspect was more important than the chemical, and that the evolution of gas occurred from the little pockets of gas between the metal and each of the innumerable pieces of graphite.

As to the effect of carbon, when graphite or even combined carbon was in contact with enamel, there was a sudden evolution of gas and then a stoppage, the reason being that at the temperature at which the experiment was being carried out there was no dissociation of the carbon towards the surface. He could quite appreciate dissociation at temperatures of 850 deg. and above, but tests had shown that irrespective of temperature there was no prolonged chemical interaction between the carbon and the enamel.

Vote of Thanks

MR. B. B. KENT, proposing a vote of thanks to Mr. Cowan for his lecture, said that he had never before heard so much commonsense in a talk to enamellers. With regard to the point that, provided iron was good and clean, it could be enamelled, Mr. Kent said that if that were so, he would like to know why a casting could not be white enamelled so easily as it could be black enamelled.

The vote of thanks was seconded by MR. W. THOMAS (Hon. Secretary of the Southern Section of the Institute) and was carried with acclamation.

Darlington Railway Plant & Foundry Company

There is to be a change in the control and direction of the Darlington Railway Plant & Foundry Company, Limited, Bank Top, Darlington, manufacturers of points and crossings and other railway material. Thos. W. Ward, Limited, Sheffield, have acquired a substantial interest and Mr. Ashley S. Ward will be the new chairman of directors. In addition, Mr. Joseph Walton and Mr. H. W. Secker, of Sheffield, and Mr. A. J. Wainford, of Middlesbrough, have been elected to the board.

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The Newer Refractories

At a recent meeting of the Northern Section of the Institute of Vitreous Enamellers, held in Manchester, the Carborundum Company, Limited, displayed a cinematograph film depicting the manufacture of Carborundum and Aloxite for grinding and abrasive purposes. Mr. F. G. Sparshott acted as lecturer, while the film was operated by Mr. F. G. Harris.

The film, which was entitled "Jewels of Industry," depicted the celebrated scientist, Dr. Ed. G. Acheson, re-enacting, in his laboratory, the experiments which ultimately resulted in the production of Carborundum. It was a far cry from the tiny crystals as produced by Dr. Acheson to the huge electric furnaces shown later in the film. These furnaces are located at the Canadian plant at Shawinigan Falls, and in them the two abrasives, Carborundum and Aloxite, were created. The beautifully-coloured diamond-like Carborundum crystals were shown in the electric furnace at the temperature of 2,230 deg. C., being produced from such ordinary materials as coke, sand, sawdust and salt. The process of creating Aloxite in the electric arc furnaces from coke and the aluminous clay bauxite was also shown.

Ships were seen transporting the raw Carborundum and Aloxite across the Atlantic, and along the Manchester Ship Canal, to the industrial area of Trafford Park, with its 7 miles of quays and 120 miles of dock railways. Here the materials were delivered direct into the siding of the plant of the Carborundum Company, Limited, where they were manufactured into grinding wheels of all conceivable shapes, sharpening stones, refractory materials, crucibles, etc.

Finally, the film took the observer on a tour of some of the most important engineering workshops in Great Britain in which Carborundum and Aloxite brands of grinding wheels were seen at work.

Manufacturing Processes

From a technical point of view, it was explained that Carborundum was the trade name of carbide of silicon and was a chemical combination of two elements—carbon and silicon. It was discovered and first produced by Ed. G. Acheson, in 1891. The crude material was composed of a mass of hexagonal crystals, diamond-like in hardness, brittle and extremely sharp, which properties made it an ideal abrasive for grinding cast iron, low-tensile metals, and other materials.

Petroleum coke (carbon) and silica sand (silica) were the chief raw materials used in the manufacture of this abrasive. These materials were mixed in the correct proportions and loaded into electric furnaces. These furnaces each required a current of 2,000 electrical h.p. for 36 hours, a total consumption of 72,000 h.p. hours for each run. By this energy the masses of coke and sand were raised to a temperature of about 2,230 deg. C. and the carbon and silica united produced crude Carborundum. At this elevated temperature all known metals were not only melted but volatilised. After the current had been turned off and the furnace cooled sufficiently, the outer crust was removed and the crystalline Carborundum exposed and then removed in large masses, which in turn were crushed to grain form.

Aloxite was another manufactured abrasive—a mixture of bauxite ore and ground petroleum coke—known technically as crystalline alumina. It was a product of the electric furnace of the arc type, and was fired at a temperature of approximately 1,926 deg. C. Aloxite was taken from the furnace in the form of immense pigs, which were broken down into large size lumps. The lumps were converted into the grain and powder form by being crushed in specially designed machines.

Both Carborundum and Aloxite grains were chemically treated and washed, thus removing all foreign materials. They were then graded to various degrees of fineness and coarseness by sieving through a series of screens, which were numbered by the number of threads per linear inch, as example: No. 30 grain indicated having passed through a screen having 30 threads to the linear inch, but would not pass through anything finer. The grains were prepared in all sizes from No. 6 to No. 220. Grains finer than 220 were called powder and were graded by settling in water.

Refractory Properties

Carborundum was a refractory material of the highest order. When bonded with a suitable binder and made into brick and special shapes known as Carbofrax, it was found to have great refractory value. Being produced in the intense heat of the electric furnace, it could not be melted; it possessed an extremely low coefficient of expansion, coupled with high thermal conductivity. It withstood the highest temperature, resisted abrasion, and did not spall or crack under rapid changes of temperature. Its great value in the upkeep of high temperature furnaces was definitely established.

Vote of Thanks

On the motion of The CHAIRMAN (Mr. H. Bradley), seconded by MR. W. H. WHITTLE, a hearty vote of thanks was accorded to the Carborundum Company, Limited, for their courtesy in permitting the film to be displayed.

DISCUSSION

In the course of the discussion which followed, MR. W. H. WHITTLE said he was of opinion that the Section was more interested in the muffle or furnace side of the use of Carborundum. Perhaps an explanation would be given in regard to the different grades of materials produced by the company, such as Carbofrax and Alfrax, and their advantages when used for the purpose of flues and muffles.

Uses of the New Refractories

MR. W. B. CLEVERLY (Carborundum Company, Limited) thought that most members were familiar with the type of muffles built by his company. Two types of brick were mainly used, "Carbofrax" and "Alfrax," the basic materials being Carborundum and Aloxite respectively, both of which were made as depicted in the film. The subsequent treatment was not exactly the same, as the materials were intended for different purposes. The open, porous nature which was necessary for grinding material was not required for refractories. The bricks were pressed by hydraulic presses and the essential difference between the two types of material was probably the thermal conductivity. "Carbofrax" brick had a conductivity 8 to 10 times that of ordinary firebrick, while "Alfrax" was midway between "Carborundum" and firebrick.

The type of brick used in the muffle depended largely upon the individual circumstances or conditions under which the muffle was to be used. Generally speaking, for the wet process of enamelling cast iron, *i.e.*, low temperatures, a "Carbofrax" muffle would be used. For sheet iron and steel temperatures "Alfrax" was to be preferred, whilst for still higher temperatures such as bath enamelling, "Carbofrax" was used. The reason for this was that at the medium temperatures there was a tendency for decomposition of the "Carborundum," with a subsequent expansion and reduction in life. In some cases it had been found that even for medium temperature work "Carbofrax" was more economical than "Alfrax" owing to its higher conductivity resulting in greater fuel saving. Generally speaking, the replacement of a fireclay muffle by a "Carbofrax" muffle would result in not less than 25 per cent. fuel saving. In some cases it was considerably higher. This depended on the muffle design and the methods of running the furnace. In first cost "Alfrax" was 10 per cent. cheaper than "Carbofrax."

Thermocouple Protection

Another application for "Carbofrax" was as thermocouple protection tubes. "Carbofrax" tubes could be used in the muffle as the outer sheathing of a noble metal couple in conjunction with an impermeable inner sheath. It should not be used without the latter for the reason that the reducing atmosphere generated within the "Carbofrax" tube was detrimental to the noble metal couple. For base metal couples the impermeable inner sheathing was not necessary.

The combustion chambers of muffles were built of the same type of bricks as the muffles themselves except that they were solid squares instead of box brick. The efficiency of the furnace depended not entirely on the material used, but also upon the design and workmanship of building which, of course, were considerations relevant to any material.

Book Review

Legierungen Der Platinmetalle Patentsammlung (The Patent Situation of Rare Metal Alloys). By A. Gruetzner and C. Goetze. Published by Verlag Chemie G.m.b.H., Berlin, W.35. Price (export), 40.50 Reich marks.

In this admirable volume Dr. Gruetzner and his co-worker, Dr. Goetze, who have already been responsible for the compilation of six similar works, have gathered together analyses and properties of all alloys of the platinum metals (iridium, osmium, palladium, platinum, rhodium and ruthenium) disclosed in the patent specifications of Germany, Great Britain, France, Austria, Switzerland and U.S.A. during the period 1886 to May, 1937. The arrangement adopted in the volumes that have previously appeared has been excellent, but this volume is still better arranged and consequently easier to use, and it is possible to trace any desired alloy within less than a minute.

Although the book is in the German language, the arrangement is such that no knowledge of that language is necessary if one wishes to find particulars of disclosed analyses and the specifications in which they have appeared, but in order to understand the particulars concerning the properties a slight knowledge of German is necessary.

Although this work is probably intended for the use of patent agents, it should be in the hands of every metallurgist working with metals of the platinum group. It also makes interesting general reading, if one may use the word "reading" in connection with a book consisting of a series of tables. It is, for instance, interesting to observe the number of analyses that may be disclosed in a single patent specification; German patent No. 373,725 of 1919 discloses approximately 1,200. It is also of interest to compare the analyses disclosed in this volume with those in the volume dealing with iron and steel alloys. In the case of the iron and steel alloys, the majority of patent specifications disclose precise analyses, *i.e.*, the analysis of the alloys is definitely stated as percentages. When one turns to this present volume, however, one finds that in numerous cases the patentee has contented himself with disclosing only the constituents in the alloy and not the proportions present. This seems to indicate that metallurgists working in this field have not advanced as far in their art as those dealing in iron and steel alloys.

J. F. K.

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- Low Carbon Malleable (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

Typical Cylinder Pig Iron Specification

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

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The Week's News in Brief

Trade Talk

THE GREAT WESTERN RAILWAY COMPANY have under consideration the electrification of the line from Taunton to Penzance.

THIS WEEK is the fiftieth anniversary of the invention of the pneumatic tyre by John Boyd Dunlop, a Belfast veterinary surgeon.

THE ANNUAL DINNER of the East Midlands Branch of the Institute of British Foundrymen was held at the Assembly Rooms, Derby, last Saturday.

THE FOREMEN of International Combustion, Limited, Derby, held their annual dinner at the Osmaston Park Hotel, Derby, last Saturday.

THE METALLURGICAL DEPARTMENT of the Sir John Cass Technical Institute, London, is installing a 50-ton tensile-testing machine by A. Macklow-Smith, Limited, of London.

TYNESIDE CIVIC CHIEFS and representative industrialists, at the invitation of Commander Sir Charles Craven, are to tour the Scotswood and Elswick Works and Walker Naval Yard of Vickers-Armstrongs, Limited, on March 10.

AN ORGANISED VISIT of members of The Institute of Vitreous Enamellers to the works of Bradley & Foster, Limited, Darlaston, Staffs, will take place on March 10. Members participating are asked to assemble at the main entrance to the works at 2.30 p.m.

BERTRAMS, LIMITED, engineers and ironfounders, of Edinburgh, have commenced the delivery of 700 tons of papermaking machinery, which is to be shipped to the South African Pulp and Paper Industries, Limited. Bertrams have been engaged on this order for eleven months.

THE ANNUAL STAFF DANCE of the Electric Furnace Company, Limited, was held last Friday at the Westminster Palace Rooms, London, S.W.1. Mr. D. F. Campbell and Mrs. Campbell received a number of distinguished guests, many of whom were prominent in the foundry industry.

THE BRITISH IRONFOUNDERS' ASSOCIATION, who are organising a competition for the best slogan for cast iron, announce that approximately 30,000 entry forms for the competition have been received, and at the rate entries are arriving there is a probability that over 50,000 will be received before the entry is closed.

CONSIDERABLE DAMAGE was caused by fire on Saturday at the Auchtermuchty (Perth) foundry of Robert Ferlie & Sons. The local fire brigade succeeded in confining the outbreak to the pattern store, where it originated and which was almost completely gutted; but arrangements have been made to carry on business as usual.

THE SECOND of a series of film shows was given by General Refractories, Limited, at their London headquarters, Russell House, Adelphi, on Friday last. Two of the films depicted the production of refractory bricks at the Ambergate Works and at the works of J. Grayson Lowood & Company, Limited, whilst the third was an extremely interesting record, largely in colour, of Mr. Frank Russell's recent visit to America.

BRITISH ELECTRO METALLURGICAL COMPANY, LIMITED, have commenced operations in their new works at Wincobank, near Sheffield, for the manufacture of ferro-alloys. The first furnace put into operation by the company is manufacturing ferro-chrome. The company is under the management of Sir Edmund Davis, chairman, and Mr. R. C. Brown, managing director. Mr. R. C. Brown is also the managing director of British Acheson Electrodes, Limited, of Sheffield.

AN INVENTIONS COMPETITION is being organised in connection with the next Foire de Paris, to be held from May 21 to June 6 next. Details of the competition, which is free to all competitors, can be had from the London office of the Exhibition, 17, Tothill Street, Westminster, London, S.W.1. The exhibits are to be classified in two groups :—I (*a*) machinery, motor cars, aviation, cycles, and (*b*) electricity, wireless, music, photography, cinema; and II (*c*) toys, games, sport; (*d*) heating, lighting, hygiene, household articles, and (*e*) furniture, decorative arts, advertising and education. The prizes will consist of medals, diplomas and money, whilst a sum of 25,000 francs (£200) has been placed at the disposal of the Jury by the Committee of the Foire de Paris. The closing date is March 31, 1938.

Personal

MR. R. R. STOKES, who was elected Member of Parliament for Ipswich in the recent by-election, is chairman and managing director of Ransomes & Rapier, Limited, engineers and ironfounders, of Ipswich.

MR. H. H. BURTON, who succeeded the late Mr. J. H. S. Dickenson as chief metallurgist of the English Steel Corporation, Limited, in January, 1935, has been appointed a special director of the company.

MR. CHARLES S. GILL, who for the past fourteen months has been commercial manager with the Davy & United Engineering Company, Limited, has now been appointed director and general manager of Davy & United Roll Foundry, Limited. These works are being completely modernised and extended.

MR. D. E. ROBERTS, of Cardiff, was recently installed as the President of the Institution of Mechanical Engineers for 1938-39, in succession to Sir John Thornycroft. Mr. Roberts is a consulting engineer. He received his training at the Dowlais Ironworks, where he became assistant engineer, and eventually chief engineer to the company, a post he held for several years. For more than 30 years he has been in private practice, dealing primarily with iron and steelworks engineering. He has been a member of the Institution of Mechanical Engineers for 35 years, and in addition he is a member of the Institution of Civil Engineers and the Institution of Electrical Engineers. He is a member of the Iron and Steel Institute, has also been a member of the South Wales Institute of Engineers since 1903, was President in 1922, and was created one of that Institute's few honorary members in 1927.

MR. HENRY BELL, commercial manager to Carron Company for the past eight years, has been appointed managing director of Lane & Girvan, Limited, ironfounders, Bonnybridge. He commenced his new duties on Tuesday. Mr. Bell is a native of Falkirk, and began his business career in the service of local foundries. Twenty-eight years ago he joined Carron Company as Midlands representative in Birmingham, staying there for twenty years. In 1930 he returned to Falkirk to become commercial manager of the company's Mungal Foundry. To mark the occasion of his departure from the service of Carron Company, Mr. Bell was met on Friday last by the members of the managerial staff and presented with a gold wristlet watch. Mr. George Pate, O.B.E., J.P., manager, who made the presentation, referred to the long and efficient service which Mr. Bell had rendered to the company, and wished him every success in his new position.

Obituary

MR. ERNEST WILSON, general manager of Fraser & Chalmers Engineering Works, died on Friday, February 18, after a short illness, at the age of 63. Mr. Wilson began his career in the General Electric Company, Limited, in 1892, and after nine years in various departments of the company in London, he went, at the starting of the engineering works at Witton in 1907, to take charge there of the commercial affairs. He occupied this position until 1918, when the G.E.C. absorbed Fraser & Chalmers and he went to Erith as general manager.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

British Chemical Plant Manufacturers' Association, 166, Piccadilly, London, W.1. (Company limited by guarantee.)—Executive Committee: J. H. G. Monypenny, William Russel, W. S. Knight, Dr. G. E. Foxwell, A. J. S. Hooton, Dr. R. Lessing, J. W. Wright, B. L. Broadbent and S. J. Ralph.

Correction

In the will of the late Mr. A. F. Jellyman, of Cannock, printed on this page last week, the amount should have been given as £3,921, instead of £1,549.

Contracts Open

Leek, March 7.—Cast-iron goods, for the Leek Urban District Council. The Clerk to the Council, Town Hall, Leek.

Shrewsbury, March 5.—Cast-iron goods, for the Salop County Council. Mr. Wm. H. Butler, county surveyor, School Gardens, Shrewsbury.

Rowley Regis, March 11.—Cast-iron work, etc., for the Borough Council. Mr. Clifford Buckley, Council House, Old Hill, Staffordshire.

Birmingham, March 7.—Cast-iron pipes, etc., for the Gas Department. The Chairman of the Gas Committee, Council House, Birmingham.

Doncaster, March 5.—Cast-iron and spun water pipes and special castings, for the Town Council. The Water Engineer, 2, Priory Place, Doncaster.

Wallingford, March 10.—Supplying and laying of 320 yds. of cast-iron water main, for the Town Council. Mr. F. R. Hedges, town clerk, Wallingford.

Horsham, March 21.—Spun-iron pipes and specials, iron-foundry work, etc., for the Chanctonbury and Horsham Rural District Council. Mr. F. F. Haddock, clerk, Comewell House, North Street, Horsham.

Brighton, March 10.—60-in., 54-in. and 40-in. cast-iron pipes, tees and specials, for the Town Council. Mr. W. N. C. Clinch, engineer, Brighton Corporation, Electricity Undertaking, Electric House, Castle Square, Brighton. (Fee £2 2s., returnable.)

Spenborough, March 5.—Cast-iron and spun gas mains; wrought-iron tubes and fittings; wrought-iron and steel bars, plates, bolts, nuts, lead and compo pipe and pipe hooks; cast-iron lamp columns, etc., for the Gas Department. Mr. A. L. Jennings, engineer, Gasworks, Cleckheaton.

Company Reports

Delta Metal Company, Limited.—Net profit for 1937, after distribution among the employees, contribution to employees' pension fund reserve, N.D.C. and income-tax, £115,140; brought in, £12,713; dividend of 12½ per cent. and a bonus of 4s. per share, both free of tax, £97,500; written off premises, plant and installation account, £10,000; carried forward, £20,353. Meeting, March 8.

Hammond Lane Foundry Company, Limited.—Profit for 1937, after providing for depreciation and all charges in connection with the increase of capital and issue of 60,000 preference shares, £20,058; available after income-tax and Corporation Profits Tax, £13,251; brought in, £3,644; interim dividend of 5 per cent., £3,875; final dividend of 10 per cent. on the ordinary shares, £7,750; dividend on the preference shares of 6 per cent., £573; to general reserve, £1,500; carried forward, £3,197.

Forthcoming Events

MARCH 8-10.

Institute of Metals :—Annual general meeting, at Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.

MARCH 10.

Institute of Welding (Liverpool Branch) :—"Metallurgy of Welding," Paper by H. Harris, at City Technical College, Liverpool, at 7.30 p.m.

Institution of Mechanical Engineers (Yorkshire Branch) :—Works visit to David Brown & Sons (Hudd.), Limited, Huddersfield, at 2.45 p.m.

Institute of British Foundrymen

MARCH 8.

Burnley Section :—Annual general meeting; two short Papers, at Municipal College, Ormerod Road, Burnley, at 7.30 p.m.

MARCH 11.

Middlesbrough Branch :—Annual general meeting, at Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough.

MARCH 12.

Scottish Branch :—Annual general meeting; "The Fettling Shop," Paper by J. Cameron, Jun., at Royal Technical College, Glasgow, at 4 p.m.

West Riding of Yorkshire Branch :—Joint works visit with Lancashire Branch to Thorncliffe Works of Newton Chambers & Company, Limited, near Sheffield, at 3 p.m.

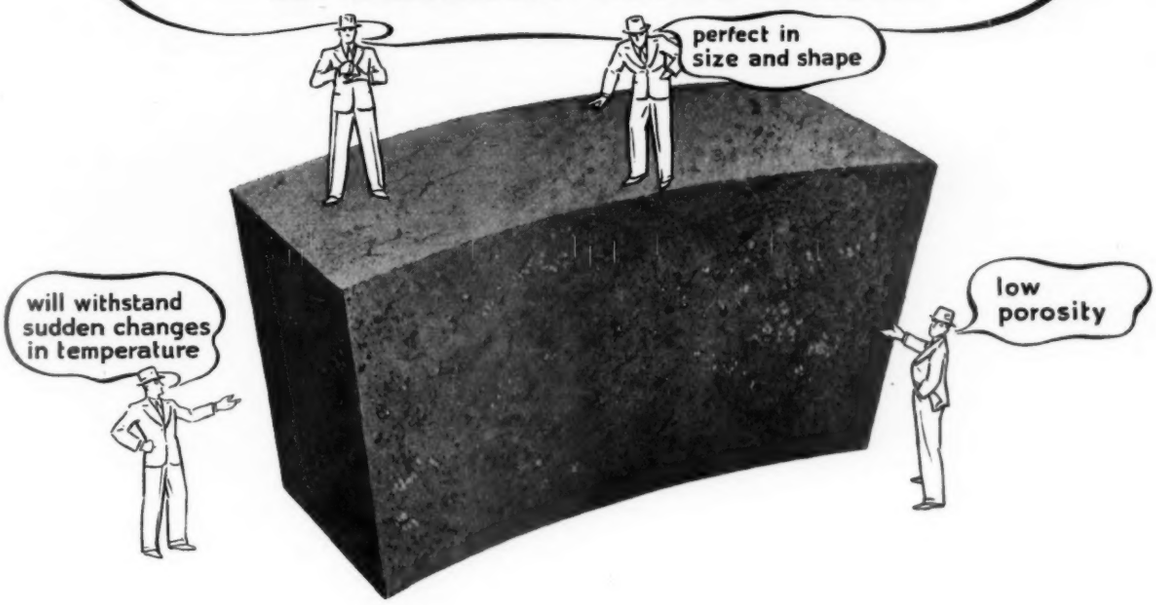
The Institute of Vitreous Enamellers

MARCH 10.

Midland Section :—"Manufacture and Use of Sheet Iron for Enamelling," Paper by J. S. Walton, at Chamber of Commerce, New Street, Birmingham, at 7.30 p.m.

Northern Section :—Three short Papers, by members, at Queen's Hotel, Piccadilly, Manchester, at 7.30 p.m.

Reliability - is certainly the word to describe these bricks



You can safely rely on the firebricks supplied by the General Refractories Group of Companies giving you satisfaction in every respect. They withstand high temperatures and sudden changes of heat without melting or splitting, and their low porosity enables them to resist abrasive forces and slag action. The utmost care is taken in the production of both standard sizes and special shapes, so that they are always of the same high quality.

We supply firebricks from Scotland, Sheffield and Stourbridge, and can therefore provide you with exactly the right quality to suit your needs. Please write for further information.

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SCOTTISH OFFICE: 48, West Regent Street, Glasgow, C.2. Telephone: Douglas 6108 (3 lines). Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson).

SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs., Exchange Place, Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place, Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

The absence of new business continues to be a feature of the iron and steel industries. While the lack of home inquiries is understandable, the quietness of the export section is somewhat disturbing.

Pig-Iron

MIDDLESBROUGH.—Deliveries of Cleveland foundry iron under contracts are satisfactory and most consumers have good tonnages on hand. Stocks are being built up at many of the works, as it is realised that, should the demand increase to any extent, the current production would be severely taxed. For delivery up to the end of June in the Middlesbrough district, No. 3 Cleveland G.M.B. foundry iron is quoted at 109s. per ton, with No. 1 foundry at 111s. 6d., and No. 4 foundry and No. 4 forge at 108s., all less 5s. rebate.

New business in hematite is largely confined to small parcels, while the export demand appears completely to have dried up. The outlook on home account is not viewed pessimistically, as it is appreciated that there is no real incentive to consumers to buy in view of the fact that prices have been fixed up to the end of the year. Prices for home sales of East Coast mixed numbers are 132s. 6d. delivered North-East Coast, 138s. in Sheffield, and 143s. 6d. in the Midlands, all less 5s. rebate.

LANCASHIRE.—The pig-iron market in this area continues to show little activity. Consumers, with certain exceptions, are employed quite satisfactorily, but there is no need for them to enter into new business on a large scale. Hematite, also, is quieter and prices have been stabilised for the whole of the year. For delivery in the Manchester price zone, Derbyshire and Staffordshire No. 3 is quoted at 114s. per ton, with Northamptonshire at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. West Coast hematite is quoted at 141s., with East Coast iron at 140s. 6d., delivered in Manchester and district, and subject to 5s. per ton rebate. Scottish No. 3 is quoted at around 141s. per ton.

MIDLANDS.—There is still no improvement to report in working conditions at the consuming plants and the immediate outlook is unsatisfactory. Largely under the influence of the rearmament programme, the heavy engineering concerns are active and deliveries of pig-iron to these establishments are fully maintained. It is generally expected that there will be a revival among the light-castings, electrical and jobbing foundries during the second quarter of the year. The motor trade, also, is likely to become more active within the next month or two. The controlled prices for ordinary Midland No. 3 foundry iron are £5 11s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, and £5 8s. 6d. for Northants No. 3, delivered to Birmingham and Black Country stations, and subject to 5s. rebate. The controlled values for hematite are £7 3s. 6d. for East Coast No. 3 and £7 4s. 6d. for West Coast mixed numbers, delivered South Staffordshire stations, and less rebate. Hematite is available in adequate tonnages. The demand for low-phosphorus iron is strong and the heavy engineers, particularly, are taking up large supplies. The price of this iron ranges from £6 5s. to £7 7s. 6d. for delivery to the Midlands. Refined iron is quoted at £8 5s., but less is being paid by consumers dealing with producers outside the Association.

SCOTLAND.—The foundry iron market remains quiet and new business is very small at the present time. No. 1 foundry is quoted at 120s. 6d., with No. 3 at 118s., f.o.t. furnaces. Hematite and basic are both being well taken up. Local steelworks are working to full capacity and there is every prospect of this satisfactory condition obtaining for a considerable time to come. Hematite mixed numbers are quoted at 133s., with Scottish basic at 107s. 6d., and English and Indian basic at 100s., less 5s. rebate, delivered f.o.t. steelworks.

Coke

Prices of foundry coke have been fixed at current levels for deliveries up to the end of the year, but consumers are in doubt as to whether they will be maintained for so long. Consequently, business is restricted. For delivery to Birmingham and district, best Durham coke is quoted at 55s. 9d., and Welsh coke at from 55s. to 62s. 6d., according to quality.

Steel

Trading in the steel markets has developed a certain amount of irregularity, says the official report of the London Iron and Steel Exchange. While the heavy steel section of the industry is well employed and customers are still exercising pressure to obtain deliveries, some of the lighter branches are experiencing quiet conditions. A very heavy tonnage of steel, however, is passing into consumption and the requirements of users remain at a high level. Easier conditions have developed in the semi-finished steel department, and consumers are now obtaining all the material they require. The imports of foreign steel arranged for some time ago are arriving in considerable tonnages, and as a result this section of the market has a rather congested appearance. In the finished steel branch of the market, the demand for joists and sectional material is well maintained, and long delivery periods are asked in the case of some specifications. The export trade remains quiet, but inquiry from some overseas markets has been more active than of late.

Scrap

Imports of scrap iron and steel in January, at 219,700 tons, amounted to what is probably a record figure. In December, the quantity imported totalled 76,900 tons, and the average monthly import in 1937 was 79,200 tons. Scrap suitable for the steelworks continues to be well taken up, but there is less demand for ironworks' and foundries' qualities. Supplies, in most instances, are plentiful, although there is still some difficulty in obtaining adequate tonnages of some descriptions.

Metals

The recent improvement in price levels has not been accompanied by any notable expansion in business, although there are signs, here and there, that activity among industrial concerns will pick up within a month or two. Meantime, political influences continue to decide the trend of the markets to a large extent.

Copper.—There has been a fairly good tone ruling during the past week, but consumers still decline to do much business. Although small tonnages are changing hands, trade in the United States remains very dull, and consumption of copper is low. The Metallgesellschaft reports that the world's smelter production of copper totalled 173,448 metric tons in December, making a total of 2,289,702 tons for the year, as compared with 1,698,447 tons in 1936.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £41 3s. 9d. to £41 5s.; Friday, £40 8s. 9d. to £40 10s.; Monday, £40 15s. to £40 17s. 6d.; Tuesday, £39 15s. to £39 16s. 3d.; Wednesday, £40 5s. to £40 6s. 3d.

Three Months.—Thursday, £41 7s. 6d. to £41 10s.; Friday, £40 12s. 6d. to £40 15s.; Monday, £41 to £41 1s. 3d.; Tuesday, £39 18s. 9d. to £40; Wednesday, £40 10s. to £40 11s. 3d.

Tin.—This market is still quiet, despite a certain amount of speculative interest. The tinplate industry in this country remains dull, the lack of export orders being especially disturbing. Works are operating at around 57.5 per cent. of capacity, while the tinplate trade in the United States is working at around 50 per cent., which is an improvement on recent figures. The output of tinplates in America during January is estimated at 1,900,000 base boxes, against 2,950,000 boxes in December and 4,700,000 boxes in January of last year.

It is understood that the question whether Malaya should withdraw from the restriction scheme is under official consideration by the Governments of the Malay States. The suggestion is very unpopular among tin interests and there is general confidence that the outcome of the discussions will be adverse to withdrawal. If Malaya were to withdraw, the scheme, at least in its present form, would doubtless be abandoned. An Amsterdam report states that Dutch tin circles regard the possibility of Malaya leaving the tin restriction scheme as being very remote. It is thought there that Malaya would be very unwise to desire an end of the restriction scheme.

The February issue of the Statistical Bulletin of the International Tin Research and Development Council, issued by The Hague Statistical Office, reveals that world tin production in December, 1937, reached a figure of 27,000 tons, bringing the total for the year to a record level. As compared with 1936, production in 1937 increased by nearly 27,000 tons to 206,900 tons. World apparent tin consumption in 1937 also reached a record figure—197,300 tons, an increase of 37,000 tons on the preceding year, whereas the estimated use of tin in manufacture shows an increase of 8,000 tons to 172,000 tons. In the United Kingdom, consumption was the highest since 1928, and in Germany since 1930. In France, Italy, Poland and some other countries consumption is showing a decrease. Apparent tin consumption in the United States during 1937 was the highest on record. In nearly all large tinplate producing countries the output of tinplate reached new records in 1937. The use of tin in the tinplate industry increased from 62,000 tons in 1936 to 65,000 tons in 1937. Tinplate consumption in the United Kingdom increased by 48,000 tons to 493,000 tons, in Germany by 9,000 tons to 131,000 tons, and in the Netherlands by 12,000 to 72,000 tons. In the United States, tinplate consumption in the twelve months ended November, 1937, was 1,902,000 tons, being an increase of 83,000 tons, as compared with the preceding twelve months. During January, 1938, visible stocks decreased by 74 tons to 24,967 tons, representing 12.8 per cent. of the current annual rate of consumption.

The Metallgesellschaft announces that the mine output of tin in December amounted to 22,164 metric tons of fine tin, making a total of 207,342 tons for the year, as compared with 180,945 tons in the previous year.

Official quotations were as follow :—

Cash.—Thursday, £189 5s. to £189 10s.; Friday, £186 15s. to £187; Monday, £186 12s. 6d. to £186 15s.; Tuesday, £185 15s. to £186; Wednesday, £186 10s. to £186 12s. 6d.

Three Months.—Thursday, £189 to £189 5s.; Friday, £186 5s. to £186 10s.; Monday, £186 10s. to £186 15s.; Tuesday, £185 5s. to £185 10s.; Wednesday, £186 to £186 10s.

Spelter.—Zinc consumers, notably brassmakers and galvanisers, have displayed slightly more interest and it is hoped that this improvement will be maintained, although the immediate outlook is rather uncertain. In the United States, the production of galvanised sheets has declined to around the low level of 34 per cent. of normal capacity.

Daily market prices :—

Ordinary.—Thursday, £15 2s. 6d.; Friday, £14 17s. 6d.; Monday, £14 13s. 9d.; Tuesday, £14 5s.; Wednesday, £14 7s. 6d.

Lead.—New business is dull both in this country and in the United States. According to the Metallgesellschaft, the world's smelter output of lead in 1937 amounted to 1,653,762 metric tons, against 1,455,233 tons in the previous twelve months.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 15s.; Friday, £15 3s. 9d.; Monday, £15 10s.; Tuesday, £15 7s. 6d.; Wednesday, £15 6s. 3d.

Scrap.—Demand for non-ferrous scrap is small and is likely to continue so for some time to come. Business is confined to meagre tonnages and there is little confidence in the future.

Approximate selling prices for old metal :—New aluminium cuttings, £80; rolled, £63; cast, £38; foil, £88. Copper, £37 to £40; braziery, £34. Brass (clean), £24 to £26. Zinc, £8. Lead, £14. Gunmetal, £37 to £38.

Core-Drying Stoves

Unsatisfactory operation of the core-drying stoves of the grey-iron foundry at the Stalin motor factory, resulting in rejection of large quantities of cores on account of overburning, led to an experimental investigation in an endeavour to improve the efficiency of the stoves. The results of this are described by C. N. MAKARIN in "Liteinoe Delo," No. 8, 1937. Increasing the volume of gases passing through the drying chambers by 50 or 60 per cent. and diminishing the temperature of the gases entering the chambers from 315 deg. C. to 218 deg. reduced the drying period for large cores (cylinder blocks and gear boxes), the final moisture content and the strength of the cores dried under these conditions satisfying the necessary requirements for casting.

METALLURGICAL CONTROL ENSURES UNIFORMITY IN PRODUCTION.

It is the aim of the Company to provide customers with the highest attainable quality in aluminium and aluminium alloy products. In all phases of the production and fabrication of aluminium, fullest advantage is taken of the latest metallurgical knowledge.

THE
British Aluminium
CO. LTD

HEAD OFFICE: ADELAIDE HOUSE, LONDON, E.C.4.

Telephone: Mansion House 5561. Telegrams: "Cryolite, Bilgate, London."

F.T.J. 3.3.38

RAW MATERIALS—PRICE LIST

(Wednesday, March 2, 1938)

COPPER

	£	s.	d.
Standard cash	40	5	0
Three months	40	10	0
Electrolytic	44	0	0
Tough	42	15	0
Best selected	43	5	0
Sheets	77	0	0
India	56	0	0
Wire bars	44	10	0
Ingot bars	44	10	0
H.C. Wire rods	48	0	0
Off, av. cash, Feb.	39	12	10½
Do., 3 mths., Feb.	39	17	1⅞
Do., Sttlmnt., Feb.	39	13	0
Do., Electro, Feb.	43	19	2½
Do., B.S., Feb.	43	10	7½
Do., Wire bars, Feb.	44	7	1½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			8½d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	8d.
Yellow metal rods	6¼d.

TIN

	£	s.	d.
Standard cash	186	10	0
Three months	186	0	0
English	186	10	0
Bars	187	15	0
Straits	187	15	0
Eastern	187	5	0
Banca (nom.)			—
Off. av. cash, Feb.	183	5	3½
Do., 3 mths., Feb.	183	2	9½
Do., Sttlmt., Feb.	183	4	6

SPELTER

	£	s.	d.
Ordinary	14	7	6
Remelted	12	0	0
Hard	11	10	0
Electro, 99.9	18	6	3
English	15	7	6
India	14	0	0
Zinc dust	21	0	0
Zinc ashes	5	5	0
Off. aver., Feb.	14	9	11⅝
Aver., spot, Feb.	14	8	1⅞

LEAD

	£	s.	d.
Soft foreign, ppt.	15	6	3
Empire (nom.)	16	3	9
English	17	10	0
Sheets, home	23	10	0
Do. export	20	0	0
Pipes, home	23	0	0
Do. export	20	10	0
Tea lead	31	10	0
Off. aver., Feb.	15	9	3 3/16
Aver., spot, Feb.	15	8	0⅜

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	28	15	0	to 29	5	0
Do., V.M. ex-whse.	28	15	0	to 29	5	0
Rods				21	0	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	81	0	0	to 82	0	0
Chinese, ex-whse.	67	0	0	to 69	0	0
Crude, c.i.f.				40	0	0

QUICKSILVER

	£	s.	d.
Quicksilver	12	17	3

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.
Ferro-silicon—			
25%	12	10	0
45/50%	12	0	0
75%	17	0	0
Ferro-vanadium—			
35/50%	14/- lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	4/9 lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	9d. lb.		
Ferro-phosphorus, 20/25%	£21 to £22		
Ferro-tungsten—			
80/85%	6/- lb. (nom.)		
Tungsten metal powder—			
98/99%	6/1¼ lb. (nom.)		
Ferro-chrome—			
2/4% car.	34	15	0
4/6% car.	24	5	0
6/8% car.	24	0	0
8/10% car.	24	0	0
Ferro-chrome—			
Max. 2% car.	36	0	0
Max. 1% car.	38	5	0
Max. 0.5% car.	41	0	0
70% carbon-free	10d. lb.		
Nickel—99.5/100%	£180 to £185		
"F" nickel shot	£165	0	0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.		
Metallic chromium—			
96/98%	2/5 lb.		
Ferro-manganese—			
76/80% loose	£18 15 0 to 19	5	0
76/80% packed	£19 15 0 to 20	5	0
76/80% export	£22	0	0
Metallic manganese—			
94/96% carbon-free	1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	9	to 3	11	3
Mixed iron and steel	3	6	9	to 3	9	3
Heavy cast iron	3	8	9	to 3	11	3
Good machinery				3	15	0
Cleveland—						
Heavy steel, best	3	7	0	to 3	9	6
Steel turnings	2	13	0	to 2	15	6
Heavy cast iron				4	2	6
Heavy machinery				4	7	6
Midlands—						
Short heavy steel				3	17	6
Light cast-iron scrap				3	2	6
Heavy wrought iron	4	0	0	to 4	5	0
Steel turnings	2	6	3	to 2	8	9
Scotland—						
Heavy steel, best	3	5	0	to 3	7	6
Ordinary cast iron	4	2	6	to 4	3	6
Cast-iron borings	2	0	6	to 2	3	0
Wrot-iron piling	4	5	0	to 4	7	6
Heavy machinery	4	10	0	to 4	11	3

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	32	0	0
Brass	22	10	0
Lead (less usual draft)	13	10	0
Tea lead	10	0	0
Zinc	7	10	0
New aluminium cuttings	68	0	0
Braziery copper	29	0	0
Gunmetal	32	0	0
Hollow pewter	130	0	0
Shaped black pewter	90	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 6d.
Finished bars, 18% tungsten	4s. 6d.

Per lb. d/d buyers' works.

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
„ No. 3	109/-
„ No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
„ d/d Birm.	144/6
Malleable iron d/d Birm.	165/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
„ No. 3 fdry.	111/-
Northants forge	107/6
„ fdry. No. 3	108/6
„ fdry. No. 1	111/6
Derbyshire forge	110/-
„ fdry. No. 3	111/-
„ fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
„ No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
„ „ Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
„ fdry. No. 3	108/6
Lincs forge	107/6
„ fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0	to 13	15	0
Nut and bolt iron	11	12	6	to 12	2	6
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ⅜ in. × 4 in.				17	10	0 and up
Steel—						
Plates, ship, etc.	11	8	0	to 11	10	6
Boiler plts.	11	18	0	to 12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ⅜ in. (untested)				11	9	0
Flats—8 in. wide and over				11	5	6
„ under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. („)				18	10	0
Galv. flat shts. („)				19	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	11½d.
Wire	12⅞d.
Rods	13½d.
Tubes	18½d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
„ furnace	37/6
Durham foundry	39/6
„ furnace	32/6
Scottish foundry	42/6
„ furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes 20×14 per box	22/6
„ 28×20 „	45/-
„ 20×10 „	34/9
„ 18¾×14 „	24/9
C.W. 20×14 „	17/9 to 18/6
„ 28×20 „	35/6 to 37/-
„ 20×10 „	29/3 to 29/9
„ 18¾×14 „	20/9 to 21/3

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£12	0	0	to £13	0	0
Bars-hammered, basis	£20	0	0	to £22	0	0
Bars and nail-rods, rolled, basis	£19	0	0	to £20	0	0
Blooms	£18	0	0	to £19	0	0
Keg steel	£30	0	0	to £35	0	0
Faggot steel	£20	0	0	to £25	0	0
Bars and rods dead soft st'l	£19	0	0	to £20	0	0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

			£	s.	d.	
Feb.	24	..	41	3	9 dec.	20/-
,,	25	..	40	8	9 ,,	15/-
,,	28	..	40	15	0 inc.	6,3
Mar.	1	..	39	15	0 dec.	20/-
,,	2	..	40	5	0 inc.	10/-

Electrolytic Copper

			£	s.	d.	
Feb.	24	..	45	0	0 dec.	10/-
,,	25	..	44	5	0 ,,	15/-
,,	28	..	44	10	0 inc.	5/-
Mar.	1	..	43	10	0 dec.	20/-
,,	2	..	44	0	0 inc.	10/-

Standard Tin (cash)

			£	s.	d.	
Feb.	24	..	189	5	0 dec.	20/-
,,	25	..	186	15	0 ,,	50/-
,,	28	..	186	12	6 ,,	2 6
Mar.	1	..	185	15	0 ,,	17/6
,,	2	..	186	10	0 inc.	15/-

Tin (English ingots)

			£	s.	d.	
Feb.	24	..	189	5	0 dec.	20/-
,,	25	..	186	15	0 ,,	50/-
,,	28	..	186	12	6 ,,	2/6
Mar.	1	..	185	15	0 ,,	17/6
,,	2	..	186	10	0 inc.	15/-

Spelter (ordinary)

			£	s.	d.	
Feb.	24	..	15	2	6 dec.	5/-
,,	25	..	14	17	6 ,,	5/-
,,	28	..	14	13	9 ,,	3.9
Mar.	1	..	14	5	0 ,,	8/9
,,	2	..	14	7	6 inc.	2/6

Spelter (Electro, 99.9 per cent.)

			£	s.	d.	
Feb.	24	..	18	18	9 dec.	6/3
,,	25	..	18	13	9 ,,	5/-
,,	28	..	18	11	3 ,,	2/6
Mar.	1	..	18	3	9 ,,	7/6
,,	2	..	18	6	3 inc.	2/6

Lead (soft foreign, prompt)

			£	s.	d.	
Feb.	24	..	15	15	0 dec.	7/6
,,	25	..	15	3	9 ,,	11/3
,,	28	..	15	10	0 inc.	6/3
Mar.	1	..	15	7	6 dec.	2/6
,,	2	..	15	6	3 inc.	1/3

Lead (English)

			£	s.	d.	
Feb.	24	..	17	15	0 dec.	o/-
,,	25	..	17	5	0 ,,	10/-
,,	28	..	17	10	0 inc.	5/-
Mar.	1	..	17	10	0 No	change
,,	2	..	17	10	0 ,,	,,

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8	
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	8 18 1½	8 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 3
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 2	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936 .. .	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	12 4 11½
1938	13 5 0	13 5 0	—	—	—	—	—	—	—	—	—	—	—

* No quotation available owing to strike.

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February 25, 1938.

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